

# **Study Methodology: Value of Maritime Trade in Southeast Asia**

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with David Gregory

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A handwritten signature in black ink, appearing to read "Jerome H. Kahan". The signature is fluid and cursive, with the first name "Jerome" written in a larger, more prominent script than the last name "Kahan".

Jerome H. Kahan, Director  
Regional Studies Program  
Policy, Strategy, and Forces Division

This document represents the best opinion of CNA at the time of issue.  
It does not necessarily represent the opinion of the Department of the Navy.

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## Summary

This document consists of a collection of papers generated by the work in progress of our study, *Value of Maritime Trade in Southeast Asia*. This project for N51 examines the economic value of maritime trade through the Southeast Asian straits, given the USN mission to ensure passage through these crucial waterways. The purpose of this document is to acquaint our colleagues with our efforts so they can participate in and contribute to our discussions and help improve the final result.

This overview simply introduces the reader to the collection of working papers. First, we offer a few paragraphs on the motivation for our investigations, after which we give a brief summary of our approach. Second, we list the working documents of the appendixes, describing how they originated as the study progressed. Finally, we attach the collection of presentations, memos, and planning documents that currently make up the study's paper trail.

## Study motivation

During the Cold War, the free world faced a disciplined enemy that openly declared its intent to dominate the world, and this enemy possessed a formidable military. Under these circumstances, it was obvious that military preparedness was of crucial importance. The cost of losing a military confrontation with such an enemy would be the loss of personal freedom or life itself. The appropriate response to such a threat is to finance as strong a military as possible without threatening the economic welfare of the citizenry.

The reported end of the Cold War, however, has changed this cost-benefit calculation. U.S. leadership now faces a decision on how many military assets to deploy and how big a navy to support. In the past, protection of merchant shipping on the high seas was a key argument for supporting strong naval forces. But times have

changed, providing alternative forms of transportation. Major disruptions such as the recent closure of the Suez Canal seem to have had remarkably little effect.

Currently, the size of a nation's navy and the size of its merchant fleet seem to be unrelated. Two countries that flag large merchant fleets, Greece and Norway, have small navies. Indeed, Liberia, Panama, and the Bahamas have (virtually) no navy to protect the large merchant fleets flying their flag.

In our study, we will not determine the value of the U.S. Navy as policeman of the high seas. We will, however, quantify one aspect of the many benefits of navies as police and protectors of world trade. Our approach is to ask what would happen if certain key waterways were blocked. Measuring the costs of shipping by longer alternative routes gives us an idea of the value to society of law and order on the high seas.

The expected cost of a possible war may be given by the probability of conflict occurring times the cost of the conflict. This study measures the cost of certain hypothesized traffic blockages to merchant shipping *without* defining the world events that might have caused such a blockage. We pay no attention to any other costs, nor to the likelihood that such events might occur.

## Study approach

The documents that follow define this study in detail. Certain key elements in the study design are listed here.

- We focus on the Malacca Straits and its two key alternatives, the Sunda and Lombok Straits. These are among the busiest waterways in the world.
- We use hypothesized scenarios. We do not evaluate the likelihood of the hypothesized trade blockage. We evaluate only the costs to commercial shipping.
- We are looking at the short-run impact of a blockage, assuming that shippers have no time to adjust or compensate.

- We focus on increased “direct” transport costs. We ignore world-trade consequences (such as global commodity shortages) that might add to or compound the effect.
- We focus on the immediate impact on shipping costs, as they translate into costs to commodities when they land in port.
- We do not evaluate the consequent impact on national GNPs or “downstream” markets for the following reasons:
  - These are long-run effects outside the scope of the study.
  - No uniform econometric model of all nations appropriate for this task has been identified.
  - The economic profession disagrees on how to evaluate these effects, and the use of “multipliers” is highly controversial (some say “discredited”).
  - Many economists argue that *no* multiplier effect exists, and measuring the “shock” at the “input level” (dockside) is equivalent to measuring the shock on the “output” level (final GNP). See D. Wisecarver, “The Social Costs of Input-Market Distortions,” *The American Economic Review*, Jun 1974.
- We make no econometric effort to model the “macroeconomic” impacts of trade disruptions on national economies for the reasons cited above.
- We make no effort to model or project the long-run impact of semipermanent sea-lane blockages, which would necessarily entail modeling trade-pattern adjustments.
- We do exhaustively investigate the tariff-like cost distortion of impediments to seaborne commerce, and we try to estimate this cost as accurately as possible.
- We carefully estimate how disruption costs of certain hypothesized blockages would be distributed among vessels according to flag, as well as by nationality of ownership. This permits us to generate evidence on whose merchant fleet would be inconvenienced by the blockage.
- We carefully trace the cost of the hypothesized transportation disruption to both the importing country and the imported



commodity. This permits us to estimate the distribution or incidence of disruption costs by the importing country, as well as to evaluate the magnitude of the disruption with respect to the commodity's value.

- We use a level of detail greater than that of any study known to us. We use port-to-port vessel movements, identifying individual vessels. We analyze 38 vessel types and trade in 40 commodity groups. Such precision is made possible by the comprehensive and extensive databases employed.
- We take into account the differences in vessel-operating costs by size and type of vessel, as well as by nationality (which affects crew wages and other operating costs).
- We use a global vessel-movements database tied to a global vessel-characteristics database. This allows for analysis of each individual vessel voyage transiting our study area.
- We do not use a traffic count. Our estimates of straits transits are therefore “derived,” not observed. That is, they are based on ports-of-call data, together with vessel-operating assumptions and knowledge of merchant marine operations.

### **Key study contribution: The data**

The concept of measuring changes in transportation costs to evaluate transport benefits is not new. Engineers and economists together routinely conduct vessel, vehicle, or aircraft “traffic counts” and estimate traffic cost savings in order to conduct cost-benefit analyses of proposed civil works such as ports, roads, and airports. However, when we reviewed the literature and talked to other analysts, we made a few interesting discoveries.

One discovery was that few authors have attempted to estimate merchant vessel transport costs and relate them to an evaluation of a disruption of shipping. Knowledgeable people differ in their opinions on whether such cost considerations are significant. This difference in opinion can be resolved by reference to data via quantification of the costs given certain assumptions.

Another discovery was that no one (to our knowledge) has published a study of this type using a vessel-movements database rather than just a vessel count. A vessel count is simply a count of vessels passing by a certain observation point and contains little or no information about ports of origin and destination. So, by using a movements database, we are able to identify which countries are affected. By linking movements data to a vessel-characteristics file, we are able to identify the flag and ownership of detouring vessels. The analysis also involves linking a commodity trade-flow database with the vessel-movements database, permitting us to relate shipping costs to specific imported commodities. This degree of precision, combined with the extent of the data employed, is both unique and worthwhile.

We concluded that there is room for a considerable contribution to the dialogue by simply getting access to an extensive, complete database and processing the data appropriately. This approach leaves us with an exhaustive exercise in merchant marine traffic accounting. It may seem almost pedestrian, but it is a data-driven empirical exercise that can contribute to the debate.

### **Origins and destinations: The appropriate degree of detail**

The problem is that too much detail is available. The ship-movements data cover all coastal countries in the world, based on about 1,800 reporting harbors. To determine the number of corresponding origin-destination (O-D) pairs, one squares the total number of harbors minus one, i.e.,  $(N-1)^2$ . Suppose we aggregate from ports up to countries, where  $N$  is perhaps 150, or in theory over 22,000 O-D pairs. Even cutting back to only 50 trading countries yields over 2,400 trade links, which is too much detail when you consider that we are analyzing 40 commodities and 38 vessel types. Several thousand trade links is simply too much detail. Also, most are irrelevant to our study, which focuses on trade passing through the access straits of the South China Sea.

We found the solution to be appropriate aggregation of data. At a global level, we will aggregate to regions. The commodity-movements data are in 28 regional O-D pairs, for 40 commodities, built up from imports and exports for all maritime countries. We have thus

chosen to focus on major regions and economies, at a global level, that generate most of the world's seaborne trade. Aggregating country-to-country voyages into regional trade links will summarize the long-haul traffic transiting the study area.

On a local level, we have chosen to study in greater detail the shipping of the economies adjacent to the straits. We have also elected to look at major trading economies that are on sea lanes that pass through the study area. In other words, we take a broad view at the world level and focus on individual economies directly affected by the sea lines of communication (SLOCs) under study.

The global region-to-region links that we study will include China, Japan, Southeast Asia, the Arab Gulf, the U.S. East Coast, the U.S. West Coast, East Africa, West Africa, Europe/North, and Europe/Mediterranean. Note that "regional" includes as regions major economies clearly of interest to the study, especially Japan and (mainland) China. (Note: The rather small amount of North Korean traffic is lumped in with China.) The United States is divided into four regions. The European Community is aggregated into north and south, which is appropriate considering (for example) that Rotterdam serves as a major point of entry for several countries.

The smaller economies we have selected for detail that were immediately affected by the scenarios are as follows: Malaysia, Indonesia, Singapore, South Korea, Taiwan, and the Philippines. These are nations that are either allies of the United States or are likely to be strongly affected by the scenarios and, together with certain of the major economies listed above, account for the bulk of the intra-regional and short-haul maritime traffic under study.

## **Dynamics and the length of the disruption**

We have some historical experience on how the shipping markets respond to disruptions in trade routes. One type of experience is with labor strikes—how vessels respond either before departure or en route on learning that their destination port is blocked by a strike. The closure of the Suez Canal provides another class of historical lesson, as does the disruption of Arabian Gulf routes during the Iraq-Iran War.

This experience has provided a clear two-stage pattern. In the early stage, the origin and destination ports do not change, and the main adjustment is that vessels (where possible) sail around the blockage. The blockage is viewed as a temporary phenomenon that may clear at any moment. In the longer run, O-D ports and sailing routes change as trade adjusts. The blockage is viewed as permanent, necessitating a reorganization of world trading patterns.

Consider a vessel en route, bound from the Arabian Gulf to Japan via the Straits of Malacca. Some undefined event occurs, blocking the straits. The vessel is likely to continue en route until it arrives at a decision point a few hundred miles from Sumatra. Then it will decide whether to continue through Malacca or detour to the nearest available alternative. Now, consider a vessel about to leave port for the same voyage via Malacca, facing a possibly temporary Malacca blockage. This vessel also is likely to steam for the same decision point off Sumatra, keeping open the option of either Malacca or the alternative until the last moment. Such patterns are likely to be observed for some time.

In this study, we will focus on the near-term or “detour” response to the disruption. Long-term adjustments are certainly harder to forecast with precision. We will not evaluate “knock-on” or long-run impacts on GNP of long-run blockages, nor will we estimate the long-run offsetting reactions of the economy as it tries to compensate for the blockage. Our reasons are as follows:

- This would tend to move us from the realm of data-rich analysis to analytic speculation.
- Long-run blockages and total embargoes are very unlikely.
- We lack generally accepted economic or econometric models.
- Long-run adjustment, consequent impacts on GNP, and compensation effects are quite scenario specific.

Note that any “multiplier” effects (if they exist) tend to be offset by compensation effects.

We will initially estimate the annualized flow rates of disrupted traffic and trade, converting these rates to daily and monthly rates for evaluation.

### **Scenario structure: Orders of magnitude of disruption**

Our first scenario postulates a blockage of the Straits of Malacca. Merchantmen must detour; in particular, Singapore-bound vessels must detour through Sunda as well. Then, in the second phase of scenario one, we postulate a blockage of the port of Singapore. The second phase is an increase in severity over the first and juxtaposes the “embargo cost” of a port blockage on top of the deviation cost of forcing vessels to detour via the Sunda and Lombok Straits.

The second scenario postulates a blockage of the South China Sea on the latitude of the Spratley Islands. Nearly all north-south traffic in the region, a large percentage of Asian maritime commerce, travels through this stretch of the South China Sea. Closing this choke point causes most traffic through the Sunda and Malacca Straits to divert, principally to the Lombok Straits. In other words, given the maze of islands, reefs, and passages in the region, closing the SLOCs adjacent to the Spratleys is about equivalent to blocking both the Malacca and Sunda Straits. Scenario two then represents a worse disruption than scenario one.

The third scenario is admittedly extreme. We postulate that the archipelagic waters and harbors of Indonesia and Malaysia and the coastal waters of Malaysia and Singapore are closed. We assume that this forces vessels sailing east through the Indian Ocean bound for north Asia to detour around Australia, a wide detour. Further, we assume that many ports in the region close. This curtails much traffic and forces nations importing from the blockaded area to import from other source areas. Both the detours and the port closures of scenario three are greater than those of scenarios two or one.

For the purposes of our study, we have constructed experimental disruption scenarios of various degrees of severity. The degree of disruption goes from bad to worse to catastrophic. The idea is to estimate the magnitude of economic costs associated with the degrees of possible SLOC disruptions.

## Study outputs

The main analytic outputs are estimates of increased shipping costs defined in detail in appendixes IV and VII. They include:

- Direct transportation costs to the world merchant fleet of each blockage scenario.
- Distribution of these costs across flag, vessel ownership, and commodity markets.
- Direct transportation-cost impact on each importing country.

These analyses will permit policy-makers to identify who is affected by each scenario, as well as how much impact there is likely to be. The economic national interests of the United States and other countries will be measured, at least insofar as merchant shipping is concerned.

## Study documentation: The appendixes

The appendixes are documents generated during the evolution of the project from conception to initial implementation. They document the specific details of the plan and spell out the development of the project concept during this period.

Appendix I describes the study concept. It was written in response to interest by the sponsor in measuring the benefits of open SLOCs. Further consultations with the sponsor ensued.

Appendix II is a presentation to the sponsor that was prepared following indications of continued interest. It summarizes the basic study approach. Once sponsor interest and commitment were verified, the search began for an appropriate data set.

Appendix III spells out the data requirements for the project. Because good data are the key to a good study, we directed a data call to the two organizations that track merchant shipping vessels and movements comprehensively on a global basis: the Office of Naval Intelligence (ONI), in Suitland, Maryland, and Lloyd's Maritime Information Services LTD (LMIS), in London, England.

Appendix IV identifies the terms of reference (TOR), which define the basic calculations to be performed using the data and specify much of the required analysis. This is a basic planning document, allowing others to respond precisely to the study requirements. The TOR was prepared based on the realization that specialized skills were required to process shipping data, and that the possibility of acquiring a processed data set should be investigated. The TOR was also directed to ONI and LMIS.

Appendix V is an interim planning brief presented to the sponsor. It finalizes the scenarios to be evaluated. It also alerts the sponsor to the fact that the cost, implementation time, work effort, and scope of the project will be greater than originally anticipated. Under the circumstances, verification of strong interest by the sponsor was required.

Appendix VI is an official communication from N21 (ONI) to the president of CNA. This letter expresses interest in and support for the project. It includes an offer of ONI participation and support and recommends that CNA deal with LMIS for acquisition of the data.

Appendix VII is a detailed study proposal submitted by LMIS in response to the TOR. It spells out where the data will be sourced and how they will be processed to meet CNA's needs and the sponsor's needs. It provides defined work product deliverables and time lines on which to base negotiations for a CNA purchase order to LMIS.

Appendix VIII is a brief seeking final CNA approval. It was presented to the president of CNA and summarizes the study approach and proposed relationship with LMIS.

Appendix IX is the approved project plan.

All documents, except for the ONI letter and LMIS proposal, were written by John Noer with the able assistance of Dave Gregory.

## Appendix I: Initial study concept

**Policy issue.** Free trade in the Malacca Straits and the South China Sea is deemed of vital national interest to the United States. The policy issue is how vital is the economic component of that interest, which justifies the Navy's mission to keep open these sea lanes. In theory, war over the Spratleys could put the South China Sea off limits to shipping. Political or environmental developments could also close the Malacca Strait.

**Economic issue.** Should free trade be disrupted in the straits or in the South China Sea, how much would it cost? Which economy would bear the largest burden? Answers to these questions would permit U.S. policy-makers to prepare the appropriate response. The immediate impact of closure of a sea lane would be to drive up maritime transport costs. The follow-on economic impacts might range from recession to shortages.

**Direct transport effect.** The immediate effect of closure would be to force shipping to travel by another, longer route. These alternative routes are more expensive because greater shipping distances result in higher costs to the importer for the commodities in question. This cost impact is immediate, tangible, and measurable. The main output of this proposed study is explicit calculation of these costs as a means to evaluate the magnitude of the overall economic impact of such a closure.

**Calculating transport cost increases.** This is a straightforward data-driven exercise. We need data on the following:

- Trade flows by origin and destination ports via the straits by commodity
- Shipping route distances
- Shipping costs per tonne-mile by vessel type.



To calculate the cost “delta” we multiply the following:

- The incremental distance of the cheapest alternate route, times
- The volume of the commodity flow, times
- The cost per tonne-mile in transit.

The results permit estimation of the following:

- The overall direct-cost impact to world trade
- The cost impact by origin or destination port (economy)
- The impact on a given type of trade (e.g., oil).

It provides us with an estimate of the first-order impact and incidence of the economic shock of the shipping disruption.

**Evaluating the impact.** With the estimates of the “transport cost shock” in hand, we can evaluate the degree of economic disruption. At issue are the following:

- Which nations are affected the most?
- What is the increase in import bills for various economies?
- What percentage of each nation’s trade is affected?
- Longer shipping routes will require more hulls to carry the same volume of trade. Is there likely to be either an increase in world shipping costs or a shortage of vessels?

Note that, if well done, a data-driven study of this nature would provide a template for similar studies of other passages and waterways. These studies also would be comparable, and thus would enable the Navy to set priorities among different shipping routes.

**Data.** MarAd has data on the world fleet, shipping costs, and routes. Import and export data are also available here in the United States, as are data on oil flows. The Navy reportedly has key data on shipping movements and vessel characteristics. Two or three data issues make a visit to the region by the principal investigator desirable:

- There are some discrepancies between figures reported by “world” sources and figures reported by regional sources about world-trade shipping volumes through the straits.
- Much regional and local maritime trade may not be picked up by international sources.
- Quite a bit of trade in the area is unreported.

Part of the data-assembly exercise will be reconciliation of different sources. Obviously, the cooperation of the three regional governments would be helpful.



## **Appendix II: Study concept brief**

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*CNA Study for N51*

# **The Value of Free Transit in the South China Sea**

**For RADM Phil Dur**

**By John Noer**

**Regional Studies Program  
Jerome Kahan  
Center for Naval Analyses**

## *Free Transit, Free Trade & National Interest*

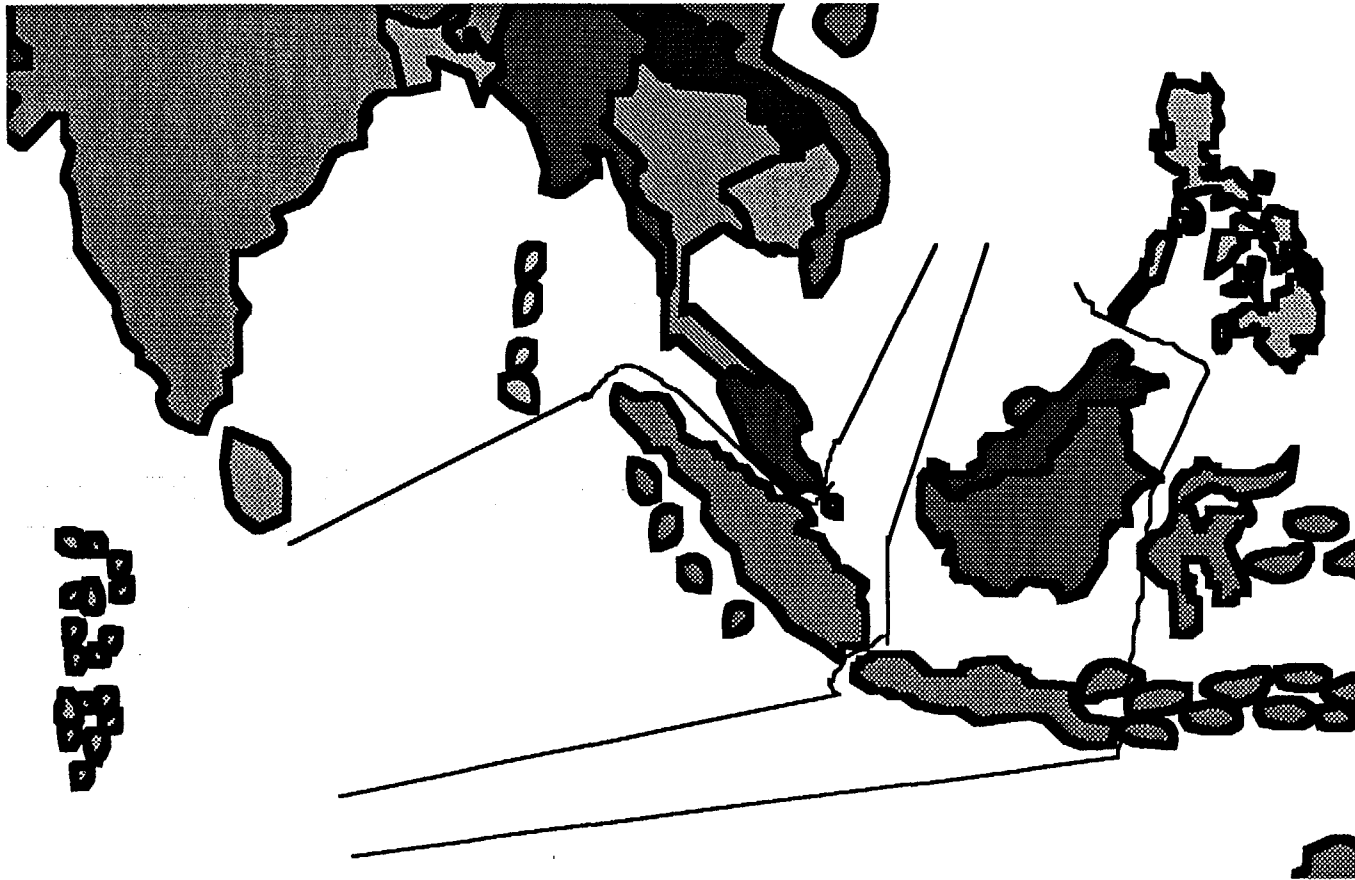
- *Malacca Straits: world's 2nd busiest sea lane*
- *South China Seas carries much commerce*
- *Closure of either would disrupt world trade*
- *Shippers forced to make wide detours*
- *How much would this cost?*
- *Who would bear the burden?*

## *Study Emphasis*

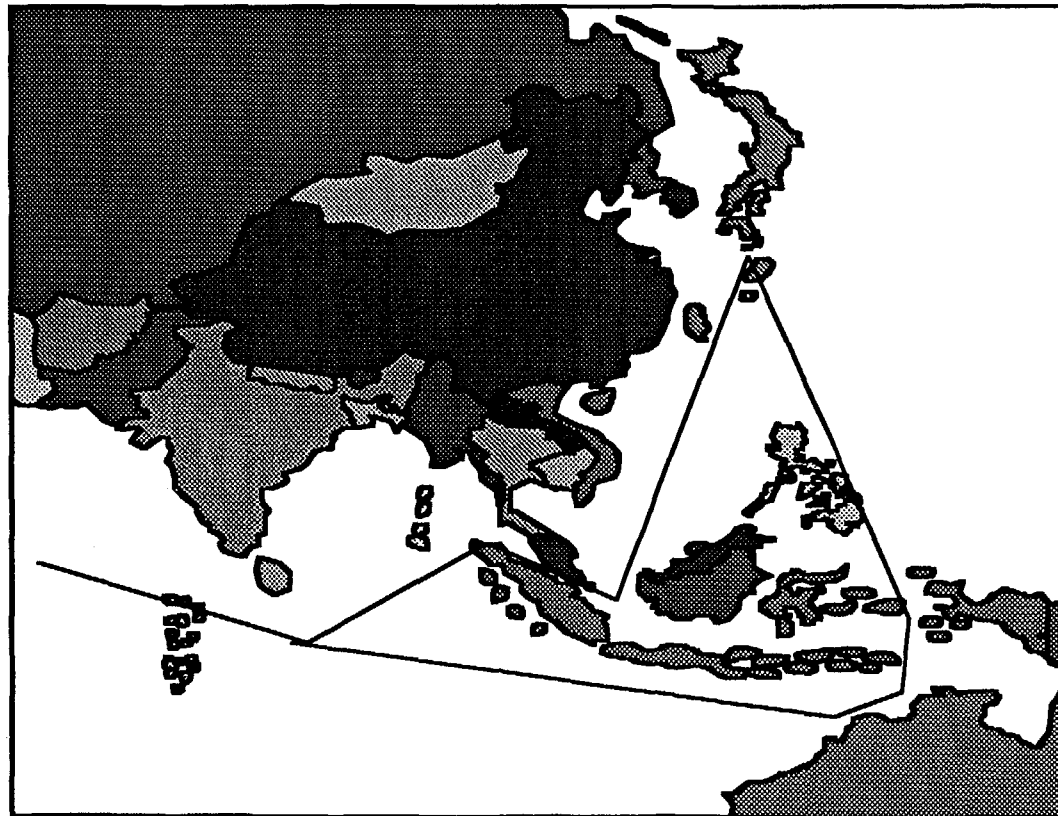
- *We do not propose to evaluate the likelihood that Malacca or South China Seas will close*
- *We do propose to evaluate the immediate costs to world trade of such closure*
- *Study output: estimate of direct transport cost, and which countries pay the costs, of disrupted trade*
- *Methodology can be applied to other routes*



## *Closure of Malacca: Diversion to Sunda or Lombok Straits*



## *An Alternative to South China Sea*



**Oil Route from Near East to Japan if Detour is Required**

## *Major Trade Flows by Commodity*

- *Crude Oil - VLCCs & Tankers*
- *Bulk Commodities - Coal, Ore*
- *Container Cargo, Break Bulk, RO-RO*
- *Shorter Haul:*
  - *Petroleum Products*
  - *Coastal Trade*
- *Main Data: Cost per Sea Mile*
  - *determinants: commodity & vessel size*

## *Direct Transport Impact Cost of Diversion*

- *Basic Premise: Traffic will find the lowest cost alternative route*
- *Sum of diversion costs for each pair of origination/destination ports by commodity*
- *For each Route & Commodity:*
  - *Extra miles sailed times*
  - *Cost per tonne-mile of cargo times*
  - *tonnes of commerce diverted*

**Commodity Flows by Origin & Destination. '000 Metric Tonnes**

**Horizontal Axis: Outbound**

[illegible]

# Trade Detour Distances

## Transportation Matrix - Diversion Distances

The Incremental Miles Sailed If The Malaca Straits Close

Symetric Matrix. Lombok Straits is Main Alternative. Nautical Miles.

From To	Shang -hai	Caton	Saigon	Hanoi	Manil la	Tokyo			Born- eo	Arab Gulf	
Shanghai											
Canton											
Saigon											
Hanoi											
Manilla											
Tokyo											
Borneo											
Arab Gulf											

## *Incidence of Impact*

- *Two main effects: 1) Tax, 2) Embargo*
- *Some economies will be denied access to imports & exports*
- *Some economies will simply pay more to trade*
- *Degree of Impact:*
  - *Very Strong Embargo Impact: e.g Singapore*
  - *Economic Impact: Japan, esp Oil*

## *Study Output*

- ***DIRECT TRANSPORT IMPACT:***
  - *Impact of Closure by type of trade: oil, etc*
  - *Impact by economy; Japan. Singapore, etc*
- ***ECONOMIC IMPACT:***
  - *Cost of Disruption as % GDP, trade*



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## **Appendix III: Data requirements**

The following represents a brief description of our data needs. We wrote these with our knowledge of existing data bases in mind. Other data of equal or superior quality and detail will, of course, be acceptable. We understand that there are many ways to approach these issues, and we would appreciate any suggestions and alternatives. Additional relevant variables are welcome. We wish data on at least five recent years, to date. Please mention caveats.

Please respond with:

- Description of data which you propose to provide.
- When the data can be provided. (Timeline of delivery.)
- Resources required of CNA.

Note: we have no desire to generate a great deal of work for you in order to respond to this request. We do however require sufficient information to prepare our budget, work schedule, and analytic approach. We will be happy to discuss the project informally with the technical people preparing the response. Please do not hesitate to contact us at any time. Please indicate to us informally as soon as possible whether or not you will respond, and if so, when.

CNA Points of Contact:

John H. Noer, Economist (703) 824-2093

David Gregory, Programmer Analyst (703) 824-2417

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## 1. Ship Movements File

We believe that we would like this data organized on a “voyage basis”, in port “origins-destinations” pairs. That is, we think our needs will be met with records organized as follows:

Table 1.

Lloyd's Reg number	Origin Port	Depart Date	Dest'n Port	Arrival Date	Route Info	Cargo Info
-----	-----	-----	-----	-----	-----	-----

To facilitate our analyses, we would like port information to include country and latitude/longitude. This is a historical data base. Please suggest a study period.

## 2. Ship Particulars File

We would like, at a minimum, the following variables:

Table 2.

Lloyd's Reg number	Capacity (tonnes)	Type Cargo	Flag	Owner	Crew (costs)	Fuel Burn /day
-----	-----	-----	-----	-----	-----	-----
Draught	Econ Cruising Speed	Vessel Type (e.g., VLCC, bulk, ...)			Etc.	
-----	-----	-----			-----	

We will need the ability to link the ships particulars file with the ship movements file (#1, by LR number) and the cost data (#3, by vessel type/capacity). This file may be broken out over time. Data on inactive or laid up vessels would be useful.

### **3. Cost Data & Vessel Categories**

In order to subdivide the fleet in a meaningful manner, we require a means of allocating individual vessels to categories according to vessel type (tanker, bulk, reefer, container, etc.) and size (cargo capacity). We understand that Lloyd's uses a 48-category breakout, which is fine by us. We must be able to link this to the Ship Particulars File (#2).

We will need to "cost" incremental time & distance sailed for each voyage/scenario. Much cost-related data is already contained in the Ship Particulars File (e.g. fuel burn.) We will require such data as require to estimate "hull rental"; which might be either based on capital cost, or on charters rates, by vessel category.

### **4. Voyage Distance Matrices**

We need to be able to assign distances steamed by route and voyage origin-destination pair. One approach is to generate a set of symmetric (or 'triangular') matrices (with zero diagonals), one matrix for each passage through our study region.

While we have not finalized the set of route alternatives with the sponsor, we anticipate requiring distance data for the following passages for each O-D pair:

Route via:

1. Malacca Strait
2. Sunda Strait
3. Lombok Strait
4. Wetar Passage
5. Torres Strait
6. Via Cape Leeuwin & Wilson Promontory (south around Australia)

Note: Since for this exercise the object is to generate "delta matrices" measuring the diversion distance in case of a sea lane blockage, simplifications are quite acceptable. We will be subtracting (say) matrix

#2 from matrix #1. So, for example, all voyages originating from or going to or via the Mediterranean might use the Port Said juncture point. Voyages passing around South Africa could reference the Cape of Good Hope juncture point. This file will link with the ship movements file (#1), possibly via the port origin-destination pairs.

## **Appendix IV: Reference terms**

### **Introduction**

Freedom of navigation as a national objective is closely allied with the concept of freedom of trade. As a thought experiment, we wish to investigate how much impediments to trade would cost world commerce in a certain set of waterways. We also wish to identify which economies might bear the burden of transit restrictions.

The study area is the South China Seas. Much international trade there is funneled through a few key Straits and along a few Sea Lines of Communication. If one route were blocked, merchant men would simply sail through the nearest available practical alternative.

Would such a detour inflict minor costs or major costs on sea borne trade? Furthermore, who would pay such costs? The implicit question is whether or not it is worthwhile economically to deploy naval forces to protect free transit by these routes, and who benefits from the presence of such deployed naval forces.

This document is intended to define the desired data collection and analyses well enough to permit the construction of an explicit work plan, budget, and schedule of delivery.

### **I. Study Objectives**

#### **I.1 Descriptive.**

As a point of departure, we wish to document the amount of maritime merchant traffic in the study area. We will present data on shipping routes, ships plying the region, and sea borne commodity flows. This exercise will characterize the importance of trade in the area to the world economy.

## I.2 Economic Importance of the Sea Lines of Communication (SLOCs).

We wish to calculate how much it would cost the world economy *in the short run* if merchant shipping could not pass certain key waterways in Southeast Asia. We assume that in the very short run, origin-destination ports would not change, and that the fleet of merchant vessels is fixed.

**Direct Impact of Blockage.** Inconvenienced long-haul shipping must steam farther, raising transport costs. We wish to estimate this cost increase, and attribute it to the commodities in transit. Ships must steam further to deliver the same cargoes. This effect may be termed the 'direct transportation impact'.

**Impact on Freight Rates.** More ships may be demanded, due to increased time in transit per voyage, reducing the excess world fleet capacity. This may put upward pressure on rates in the short run.

Shippers will pass on both sorts of cost increases.

**Detour versus Closure.** Some economies may pay a price due to higher shipping costs due to longer shipping routes for their goods. Other economies may pay a price by being unable to ship goods at all.

## I.3 Incidence of Economic Costs Due to SLOC Closure.

A main study goal is to identify which fleets and economies will pay in the event that a sea lane is closed. We wish to calculate the percentage cost increase of commodities landed in impacted countries.

**Costs to Certain Economies.** We wish to determine which commodities will require more transport costs, and which countries these goods are bound for. We conceptualize the increased transport costs as a kind of "tax" imposed on countries importing or exporting via the impacted SLOCs. We will *not* be estimating the relevant elasticities of supply and demand; but we will be estimating the magnitude of the tax-like trade barrier.

**Costs to Certain Fleets.** Certain fleets (by flag and ownership) will bear a substantial amount of the impact, at least initially. We would like to (approximately) identify these fleets.

## II. Study Scenarios

1. Malacca & Singapore Strait closed to long haul shipping.
2. Malacca & Singapore Strait closed to long haul shipping. Singapore port also closed.
3. The South China Seas, region of Spratleys closed. Most through traffic diverts from Malacca & Sunda Straits to Lombok.
4. Malaysian & Indonesian waters, and the South China Seas closed. Long haul traffic through region diverts south around Australia.

The main study focus will be the cost of traffic diversions.

In addition for each scenario a list of ports will be provided that will be considered likely to close. We wish to know in the event of closure how much commerce will be halted, under the assumption that all shipments to and from these harbors would cease.

**Scenario Results.** The results of each scenario shall be reported, by the following measures. We are concerned with both the impact overall, and the impact by certain countries.

### Magnitude of Scenario Impact (World View)

- Estimated number of vessels diverted by trade route, Strait
- Diversions by vessel type, flag & ownership
- Commodity tonnage diverted by type
- Additional vessel capacity required by vessel type
- Cost of diversion overall



### **Incident of Scenario Impact (National View)**

- Amount of tonnage diverted by commodity type by key importing and exporting country
- Number of vessels by type diverted by key importing and exporting country
- Number of vessels by type and estimated capacity diverted by flag and ownership
- Cost of diversion to key countries

### **III. Key Interim Work Products**

The final study result will be an estimate of the extra costs of shipping good farther. These final estimates will require several interim estimates as 'building blocks'. We anticipate that the basic interim work product will be matrices of estimates. There are three general types of matrices to be estimated:

- Traffic flow matrices (ships & commodities)
- Cost for incremental sailing due to scenario
- Extra time and distance in transit (scenario dependent)

There will be four sets of traffic flow matrices: a baseline (status quo), and the three scenarios. There will be one set of cost matrices; and three incremental distance matrices.

#### **III.A Traffic Matrices**

The "traffic matrices" generally conform to trade routes, the appropriate subset of port or region origin-destination pairs. Fundamental "traffic" or "shipping" matrices:

- Movements of vessels by vessel types (numbers of ships)
- Movements of commodities (tonnes of goods)

In general, country-to-country and region-to-region links are fine, so long as we get the Strait of transit right in the study area (see below)

per scenario. Note however that we must in the end sort out the cost impact by shipping & receiving country per scenario.

A major consideration for this study: for many origin-destination pairs (regions), we have to specify which Strait they sail through, i.e., for crude oil moving from the Gulf to Japan in VLCCs, we must distinguish between that which goes via Malacca and that which goes through Lombok-Makassar (and the eastbound loaded is likely to differ from the back haul deadhead.) For long-haul traffic through the region, we may use “subsoils”, –that is, for Gulf-Japan crude, there would be a subcell for each Strait.

Note that for affected ports in the region, we need descriptive statistics on commodities & vessels by type inbound & outbound.

### **III.B Distance Matrices**

These are scenario dependent. They should be in the form of “delta” matrices, the incremental distance sailed by scenario for each trade route. The delta matrices will conform to the route matrices.

Note that in certain instances, e.g., crude oil, the voyage distance of interest is the round trip, which may include a ‘deadhead’ or empty haul.

### **III.C Cost Matrices**

Two approaches are proposed: (1) Vessel-operating-expense based and (2) charter-rate based. Under the assumption that rates just cover operating expenses plus capital costs of vessels, the two are equivalent.

Vessel-operating expense builds up from cost items such as crew and fuel. Operating cost by shipping type has two parts:

- Incremental cost per extra mile steamed (distance dependent), which includes fuel burn, and other variable costs
- Incremental cost per extra day in transit. This would include “hull rental”, value of hull times the cost of capital

Charter rate approaches build up from rates currently charged by vessel type for given voyages. Both approaches may start with the assumption that world capacity is not strained by the scenarios, an assumption that might need modification if further analysis indicates that the 'sufficient excess capacity' assumption is not valid.

Allowance should be made for "cargo holding cost," value of the cargo times the cost of capital, plus any other costs such as deterioration, etc. (We can use LIBOR for the international cost of capital.)

We note that distance and time are linked to each other via economic cruising speed.

## **IV. Supporting Analyses**

### **IV.A Fleet Data**

First, we need to identify vessels which transit the study region. Then we need a breakout of these ships by size and type, by flag and ownership. We should also characterize these vessels as a subset of the world fleet. We want estimates of the number and capacity of operating ships versus laid up ships by type.

### **IV.B. Route Analyses**

General descriptive detail of traffic in the study region, for the baseline:

- Summary of east bound and westbounds
- Summary of a upbound and downbound
- Summary of trade into and out of the region
- Summary of trade within the region.

(For the last two we need some detail by port and route. For the first two we are mainly interested in the Strait used.)

## V. Final Outputs

### V.A Calculation of the Economic Costs of SLOC Closure

We wish to estimate how much it would cost the world economy to ship goods farther. We might do it either by looking at commodities or vessels (as a measure of volume); and either by reference to operating expenses or charter rates (as a measure of cost). Either of two generic formulae might apply. Note that approximations to these calculations may well suffice.

#### 1. Commodity flow based calculation.

Scenario induced increase in shipping costs,  $\partial C$ , equals:

the trade volume in the i-th commodity on the j-th trade route,  $T_{ij}$ , in tonnes;

*times* the cost per tonne-mile  $C_{ij}$  to ship the i-th commodity on the j-th trade route;

*times* the incremental distance sailed,  $\partial_{ij}$ , for the i-th commodity on the j-th trade route;

*summed* across the J trade routes;

*summed* across the I commodities.

Or:

$$\partial C = \sum_{i=1}^I \sum_{j=1}^J T_{ij} C_{ij} \partial_{ij}$$

Alternately,

#### 2. Vessel charter based calculation.

Scenario induced increase in shipping rate costs,  $\partial C'$ , equals:

the number of vessels of the k-th type on the j-th trade route,  $V_{kj}$ ;

*times* the charter rate per day  $R_{kj}$  for the k-th vessel type on the j-th trade route;

*times* the incremental distance sailed,  $\partial_{kj}$ , for the k-th vessel type on the j-th trade route, divided by the miles sailed per day at the average economic cruising speed for the k-th vessel type on the j-th route,  $S_{kj}$ ;

*summed* across the K vessel types;

*summed* across the J trade routes.

Or:

$$\partial C' = \sum_{j=1}^J \sum_{k=1}^K V_{kj} R_{kj} \{\partial_{kj} / S_{kj}\}$$

## V.B Increased Vessel Capacity Required

One might either look at extra capacity required by commodity type or vessel type.

To calculate extra number of ships required for each scenario, one approach is to calculate the extra ship-days in transit to move cargo, by type of vessel.

Scenario induced increase in shipping capacity required by type,

$\partial V_K$ , equals:

the number of vessels of the k-th type on the j-th trade route,  $V_{kj}$ ;

*times* the incremental distance sailed,  $\partial_{kj}$ , for the k-th vessel type on the j-th trade route, divided by the miles sailed per day at the average economic cruising speed for the k-th vessel type on the j-th route,  $S_{kj}$ ;

*summed* across the J trade routes.

Or, additional vessels required by type is given by:

$$\partial V_k = \sum_{j=1}^J V_{kj} \{ \partial_{kj} / S_{kj} \}$$

We might convert this to deadweight tonnes of capacity required by multiplying through by the average capacity per vessel type by route **DWT<sub>kj</sub>**:

$$\partial DWT_k = \sum_{j=1}^J V_{kj} \{ \partial_{kj} / S_{kj} \} DWT_{kj}$$

Alternately, we might look at extra capacity required by commodity. The extra capacity requirement by cargo type driven by the scenario is:

Scenario induced increase in shipping tonnage throughput

required,  **$\partial Cap$** , equals:

the trade volume in the i-th commodity on the j-th trade route, **T<sub>ij</sub>**, in tonnes;

*times* the incremental distance sailed,  **$\partial_{ij}$** , for the i-th commodity on the j-th trade route, divided by the miles sailed per day at the average economic cruising speed for the k-th vessel type on the j-th route, **S<sub>ij</sub>**;

*summed* across the J trade routes;

*summed* across the I commodities.

Or:

$$I \quad J$$

$$\partial C_{\text{cap}} = \sum_{i=j} \sum_{j=1} T_{ij} \{ \partial_{ij} / S_{ij} \}$$

Of course, the incremental tonnage capacity required for the  $i$ -th commodity group is:

$$\partial C_{\text{api}} = \sum_{j=1}^J T_{ij} \{ \partial_{ij} / S_{ij} \}$$

## V. C Incidence Of Economic Impact

We will need to get to estimates of incremental shipping cost by commodity type by country of origin & destination. The costs estimated in V.B should be allocated to receiving countries by some reasonable method.

Then these costs will be converted to measures of economic impact by converting them into "tariff equivalents". The numerator of these "tax rates" will be the incremental costs by commodity of importing the goods into a country, divided by the total value of the imports of that good into the country.

So, we'll report for each scenario the incremental cost per tonne (say) of crude oil landed in Japan, and the amount (percentage) of inbound crude in Japan affected. This analysis would support statements such as "30% of the imports of crude for country  $x$  would be directly affected, at a cost of \$18 dollars per tonne, or 6% extra per tonne imported on average". Note that we need to put values per tonne on the 40 commodity types. This would be a single set of "world prices" per commodity for most commodities.

Here's an example of an acceptable style of "tariff equivalence" analysis.

To calculate the incremental cost of importing the  $i$ -th commodity group into the  $x$ -th country perform the following calculation (or it's approximate equivalent.) For the  $x$ -th importing country and the  $i$ -th commodity on trade route  $j$ , where  $I(x,i,j) = 1$  for the  $x$ -th country importing the shipment  $T_{ij}$  and zero otherwise

$$\partial C(x)_i = \sum_{j=1}^J T_{ij} C_{ij} \partial_{ij} I(x,i,j)$$

In certain instances the term  $K(x,i,j)$  for the fraction of commodity  $i$  on trade route  $j$  destined for country  $x$  may be employed.

To compute the average tax equivalent of the hypothetical barrier on the  $x$ -th good imported into country  $x$ , calculate:

$$ATE(x,i) = \partial C(x)_i / M(i,x)$$

where  $M(i,x)$  is the value of the imports of the  $i$ -th commodity into the  $x$ -th country, which may be given by the total tonnage imported into country  $x$  times the estimated 'world price' of commodity  $i$ . The denominator may be estimated by some other method.

## VI. Work Flow

The following task flow sketches a suggested order in which to build up the analyses and estimates required. First, build up the "baseline", the description of current trade. Then estimate shipping costs per tonne. Then, build the scenario dependent "delta" distance matrices. Then, apply the delta matrices to the baseline, to get the distances of diversion. Then apply the cost matrices to calculate economic costs.



- **Baseline:**

- Identification of trade routes which pass through the study region
- Merchant fleet currently transiting the study area
- Present traffic levels & commodity flows in the area
- For key impacted countries, the amount of imports & exports passing through the Straits & the region
- Basic building blocks:
  - A set of 40 trade route matrices by commodity
  - A set of 38 trade route matrices by ship types
- Estimates of ships & commodities passing through each Strait of interest (Singapore, Sunda, Lombok)

- **Delta Matrices**

- Identify which trade routes will be affected per scenario
- Identify the alternate route for displaced traffic
- Calculate the incremental distance for each displaced trade link
- There will be 40 delta matrices, one for each commodity group
- The matrices will be the same dimensions as the traffic matrices.
- Cost Matrices
  - For each commodity type estimate the shipping cost per tonne-mile (or, the rate charged)
  - For the same commodity, the cost will vary as a function of the type of vessels used, and the proportion of the commodity shipped in each type (size) of vessel.

- **Displaced Traffic by Scenario**

- To calculate the amount of displaced shipping & commodity flow, multiply the set of baseline traffic matrices by the delta matrices
- Result:
  - Tonne-miles displaced per commodity
  - Ship-miles displaced per vessel type

- **Cost of Diversion**

- To get the economic cost per tonne-mile per commodity, multiply the tonne-miles of commodity displaced for each route by the cost matrices.
- To get the economic cost per vessel, multiply the operating cost per vessel per mile times the extra miles sailed.

- **Cost Incidence**

- To figure out which economies are affected, estimate the amount of traffic (in tonnes and ships) on each route bound for each country.
- Then apportion the costs of delay on the route to the destination countries.
- Figure the cost increase per tonne as a percentage of the value per tonne of each commodity.

- **Fleet Utilization Impact**

- Using the economic cruising speed per vessel type and the distance diverted, per scenario, figure out the extra ship-days in transit for each vessel type.
- Compare the extra total ship-days per ship type with available excess shipping. Will laid-up ships activate? At what cost?
- Evaluate the slack or lack thereof, and evaluate the expected increase in rates due to increased capacity demand.

- Factor the result back into the shipping cost to determine economic cost increases (if any) due to a rise in rates.

## **VII. Maps, Charts & Graphs**

To display the data we would like graphical displays of the data and important results. These might include charts on:

- Major trade Routes
- Tanker Routes
- Bulk Routes
- Container & Liner Movement
- Major alternate routes by Scenario
- Traffic Flows by Scenario

## **VIII. Extensions Of The Economic Analyses**

We invite suggestions for analytic items not included in the above description but perhaps readily provided. For example:

- For some low cost items (especially coal) the incremental shipping cost may immediately motivate changes in source from easily identified ports of origin.
- For some widely available goods such as oil, alternate sources might immediately come into play.

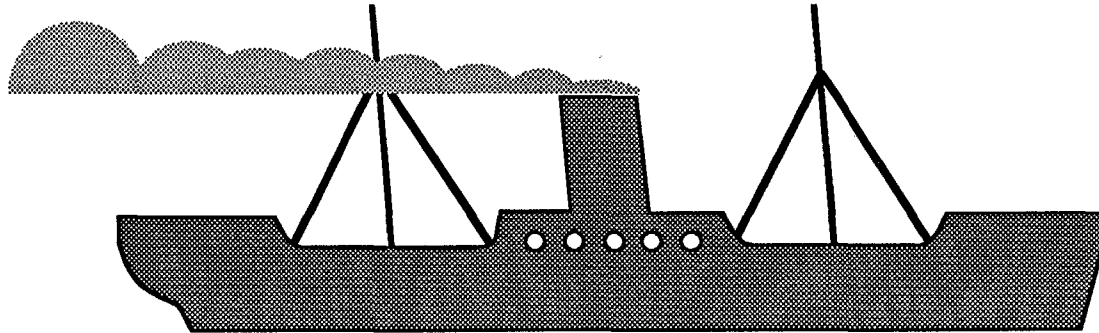
We have assumed that in the short run, origin-destination patterns and fleet capacity do not change. For a long running scenario, these factors will start to adjust. To the extent that such adjustments are forecastable, they would provide meaningful study inputs.

## **Appendix V: Flag brief: Study approaches**

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# ***CNA Strategic Trade Study for N51 “Value of Trade in South East Asia”***

## **■ Study Action Plan/Approval Brief - RADM Dur**



**By John Noer  
May 1994  
CNA Regional Studies Program  
Jerome Kahan**

# ***Study Plan Progress Report***

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- ***Update on Data & Study Plan***
- ***Flag Review of Scenarios***
- ***Revisit Budget & Timeline***
- ***N51 approval and we're ready to go!***

# ***Lloyd's Data Sources***

- ***Ships Particulars File***
  - *detail on merchant fleet over 1000 tonnes*
- ***Ship Movements File***
  - *all international merchant voyages*
- ***Charter Fixtures File - freight rates & charters***
- ***World Commodity Trade***
  - *world trade of 20 commodities on 200 trade routes*
- ***APEX - sources, routes & destinations of crude oil***
- ***Other data - Port data, liner data, vessel traffic counts, vessel operating costs, commodity prices***
- ***Recommend: data sourcing and interim processing be subcontracted to Lloyd's under CNA supervision. N-21 concurs***



# **Data Analysis**

## **- Lloyd's Task Summary**

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### ■ **Vessels & Voyages**

- ... *ID each individual ship passing thru study region*
- ... *ID all Voyages of Ships in the Region.*

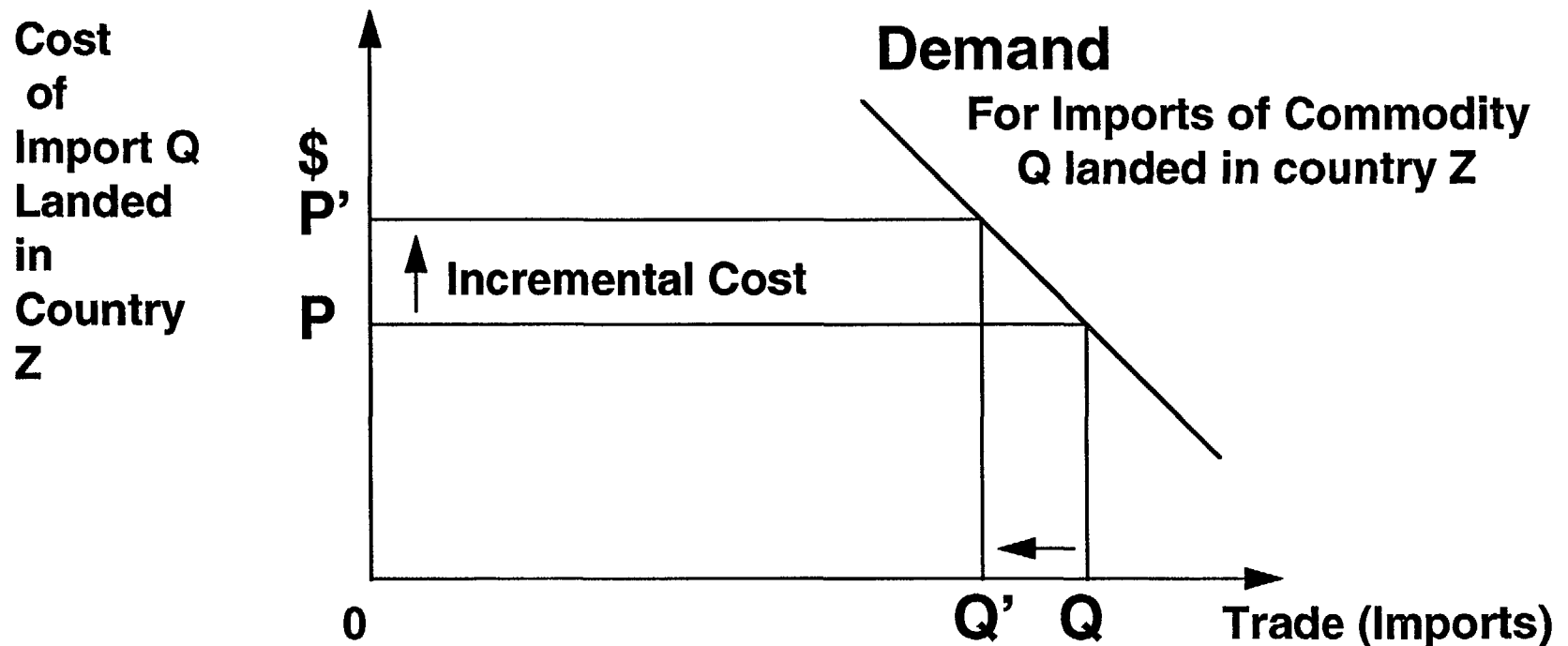
### ■ **Voyage & Trade Patterns**

- ... *Measure capacity of each SLOC by type of shipping.*
- ... *Tie commodity trade to SLOCs by ship type & route.*

### ■ **Economic Analysis**

- ... *Impact of SLOC Closure on Ships: which vessels where?*
  - » *Blockages: volume trade & ships stopped?*
- ... *Which commodities would be diverted, at what cost?*
- ... *Which economy would pay the cost, on which imports ?*

# Calculating the Economic Cost of Shipping Diversions



$$\text{Economic Cost} = [P' - P] \times Q' + (1/2) \times [Q - Q'] \times [P' - P]$$

Approximation: Incremental Transport Cost Times Trade Flow  
Summed Accross All Trade Routes & Commodities

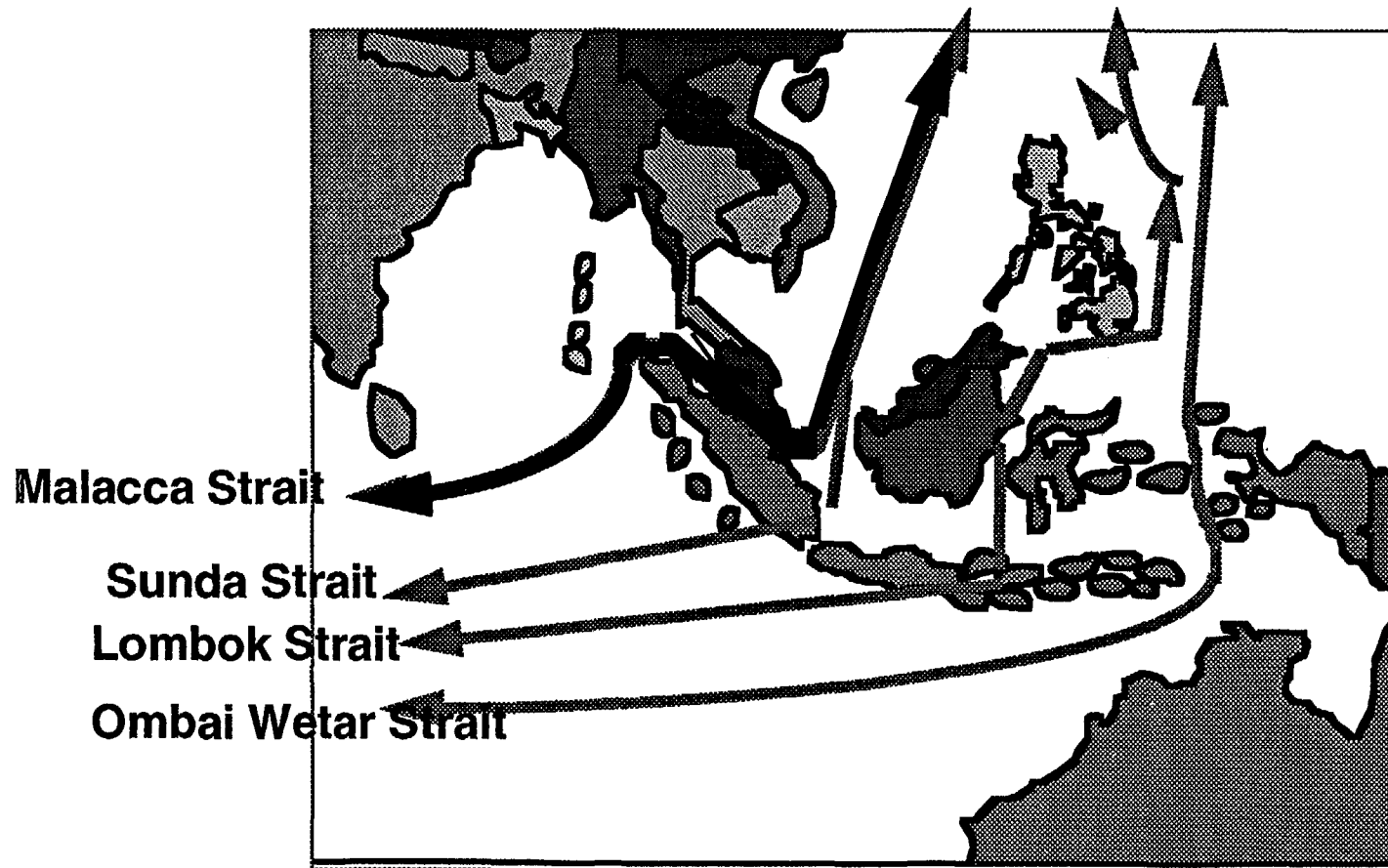
# Three Closure Scenarios

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- **We recommend 1st assuming “diversion only”, then adding in the effect of port blockage. Two versions of 3 scenarios:**
- **1) Straits of Malacca closed**
  - 1st, detour to Singapore from east
  - then - close Singapore, Port Klang, etc.
- **2) Mid South China Seas closed**
  - 1st, sea lanes cut between Spratleys & Indochina coast
  - then, coastal ports closed
- **3) Malaysian & Indonesian waters closed**
  - 1st, measure traffic that would be forced to detour
  - international, long haul trade detours around Australia
  - then, measure trade stopped in the Region

# 1. Diversion of Merchant Traffic from Malacca Straits

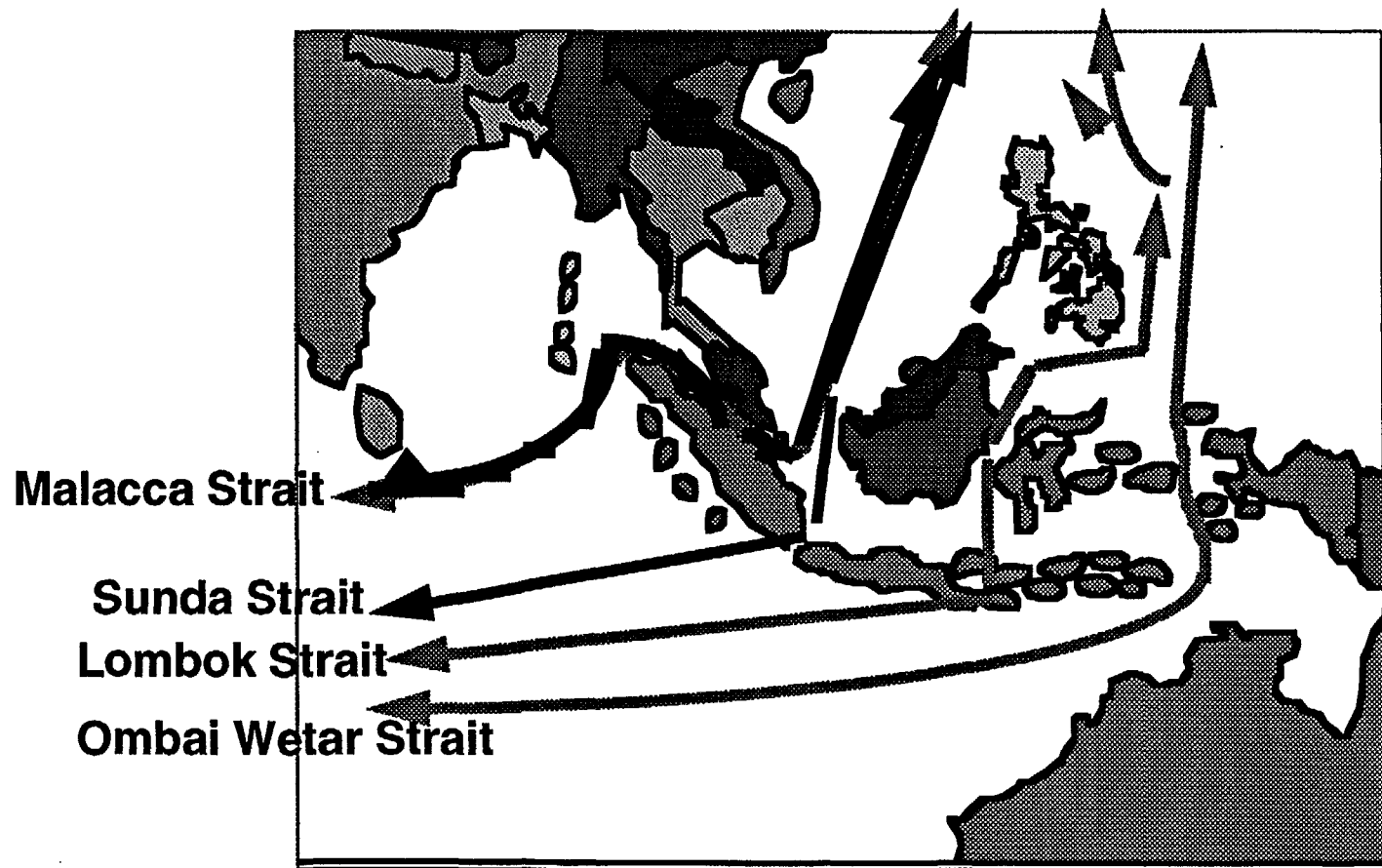
## Primary Alternate Route: Sunda or Lombok Straits



Consistent with a 'local deterrent' to shipping.

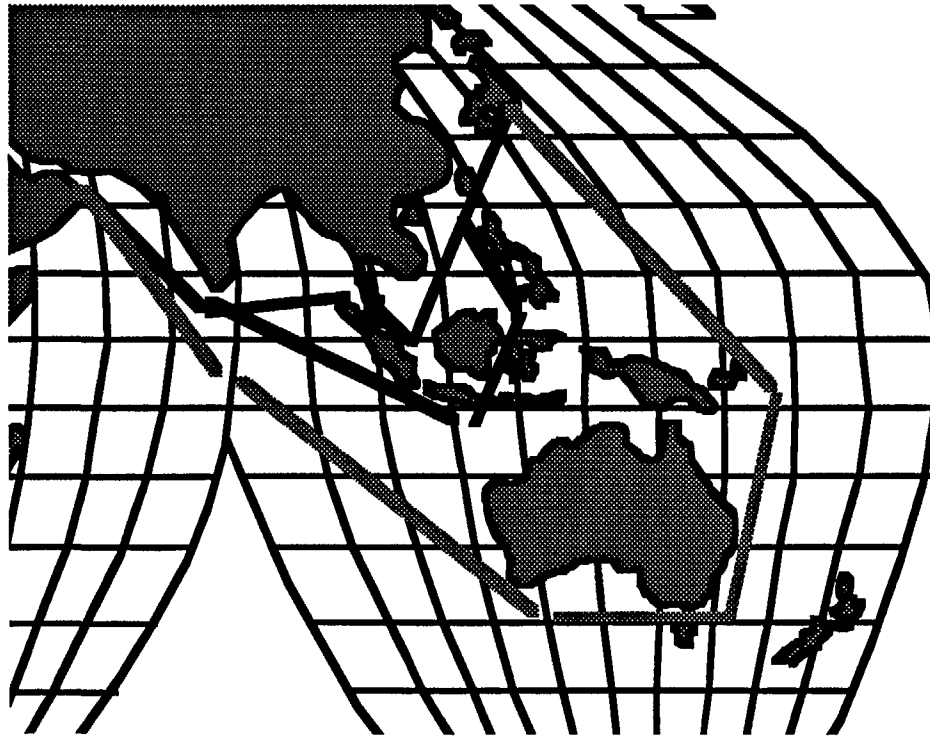
**Traditional Route**      **Detour**

## 2. Diversion of Merchant Traffic from Malacca and Sunda Straits. Primary Alternative: Lombok Straits



Consistent with closure of the SLOCs of the South China Seas, between the coast of Vietnam and the Spratley Islands.

### **3. Detour Around South China Seas. Indonesian Singaporean, & Malaysian Waters Closed. Merchant Traffic Diverts South Around Australia**



**This is an “extreme conditions” scenario.**

**———— Traditional Route**

**- - - - - Detour**

# ***Major Study Plan Modifications***

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- ***Bigger budget***
- ***Longer timeline***
  - *problem bigger than we thought, not well studied*
  - *data requirement is greater than anticipated*
  - *data bases are not well organized or easily accessed*
- ***Now, we recommend a more extensive study***
  - *to make a contribution, precision is preferred*
- ***Subcontract to Lloyd's***
  - *saves money & time, for high quality analysis*
  - *highly credible data source, not classified*
  - *co-ordinated with N-21, who recommend option*
- ***This is new ground***

## **Appendix VI: Office of Naval Intelligence letter**



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**DEPARTMENT OF THE NAVY**

OFFICE OF NAVAL INTELLIGENCE  
4251 SUITLAND ROAD  
WASHINGTON, D.C. 20395-5720

IN REPLY REFER TO  
3800  
Ser 21/0187  
29 Apr 94

From: Director, Office of Naval Intelligence  
To: President, Center for Naval Analyses, 4401 Ford Avenue,  
P. O. Box 16268, Alexandria, VA 22303-0268  
(Attn: John Noer)

Subj: DATA CALL, STUDY FOR N3/N5 AND N51: MERCHANT MARINE  
DATA ACQUISITION

Ref: (a) CNA ltr dated 23 March 1994  
(b) Meeting btwn ONI (CAPT Robinson, Charles Dragonette,  
and Nancy Walter) and CNA (John Noer and David Gregory)  
on 23 Mar 94  
(c) Meeting btwn ONI (Charles Dragonette), LMIS (Alan  
Goldman, and CNA (John Noer and David Gregory) on  
8 Apr 94

1. In response to reference (a) and as discussed references (b) and (c), the Office of Naval Intelligence Department of Civil Maritime Analysis (ONI-21) recommends that the Center for Naval Analyses work with both Lloyds Maritime Information Services (LMIS) and ONI-21 to respond to Strategic Trade questions posed by RADM Dur. The analysis proposed by Mr. Goldman in reference (c) would appear to offer the most accurate, expeditious, and cost effective solution, which would not be subject to emergent, higher priority tasking which regularly impact on various ONI long-term projects. ONI-21 remains committed to working closely with both LMIS and CNA on this project to ensure that the resulting analysis is compared and coordinated with fused intelligence available to ONI at national, all-source levels. ONI-2's technical, economic, regional, and POL-MIL expertise will be available to CNA throughout this project, particularly during the final stages of analysis, assessment, and conclusion of the study.

2. The following data are available from ONI to support the Center for Naval Analyses (CNA) task from RADM Dur (CNO-N51) should the LMIS proposal not be acceptable:

a. ONI can supply detailed voyage and tracking data for non-military maritime activity in and near the Straits of Malacca and South China Sea. The material can include the Navy control number (vice Lloyd's Register number requested), ship type, size, speed, flag, flag of owner, and rate of fuel use. ONI suggests that ship name be added to provide a cross-check; merchant ship identities change frequently. A one-year survey of data is suggested. Although data in the aggregate will be classified confidential, the macro survey desired by RADM Dur can be produced at the unclassified level. ONI proposes that the data be supplied in two

Subj: DATA CALL, STUDY FOR N3/N5 AND N51: MERCHANT MARINE  
DATA ACQUISITION

phases: The first a one-month sample for CNA to evaluate and work with; and the rest to follow when CNA is ready. Each increment can be supplied within ten working days of acceptance of the proposal. Even if CNA opts for the LMIS proposal, ONI-21 stands ready to provide a one-month data sample to CNA for review and assessment.

b. Inactive/laid up ships can be summarized from existing published reports available from Lloyd's reports as a one-time, worldwide overview specifying number of ships by type, size, and area of layup. These data will be manually culled and will be available about ten working days after acceptance of proposal.

c. Crew costs are not available from ONI. Note that costs vary both by size (number) of the crew, their nationality, and the nationality of the ship (flag) on which they serve. The best that may be available is a generic range of crew costs under given flags by ship type. Cargo carried on a per-voyage basis is similarly unavailable from ONI. Distances between ports by varying route and normal sealanes are available through commercial tables of distances.

d. Information will be produced as unreduced raw data, either in printout form or via magnetic tape as an ASCII flat file, within the ten working days cited above.

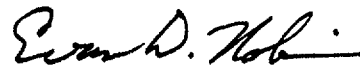
3. Based on ONI's observations in reference (b) and (c), Lloyd's Maritime Information Service (LMIS) can produce data that are very similar to those from ONI and these data can be supplied in an analytically reduced form. ONI voyage data will be more complete than that of Lloyd's in respect to the North Korean and Vietnamese fleets. Since these merchant ships are not commercially significant players in the world or regional economy, the apparent disparity will have little effect. Data for small ships (500 tons and below) in purely local trades are incomplete from both ONI-21 and Lloyds sources, and neither can be said to give a comprehensive picture of the actual traffic in such vessels. Cost and other factors for these small ships are not available and are less likely than the larger ships to be generically analyzed. Furthermore, small ships would be able to call at numerous small ports and transit via multiple, more shallow routes. The impact of closing the Strait of Malacca on the small, littoral tramp maritime trade would be very difficult to assess and ONI recommends that the CNA study be confined to the large liner trades typically employing merchant ships greater than 1,000 tons.

4. Lloyd's basic data are purchased by ONI for Navy use. As agreed in reference (c), the supposition is being made by Lloyd's

Subj: DATA CALL, STUDY FOR N3/N5 AND N51: MERCHANT MARINE  
DATA ACQUISITION

that CNA is using only such data as have been already paid for by ONI. This will reduce both overall cost to CNA and also the time required for a comprehensive response from Lloyd's.

5. ONI maintains an active interest in the region under study and all aspects of its military, political, and economic activity. As these affect national security interests and the Navy's traditional concerns with Law of the Sea and Freedom of Navigation, ONI welcomes the opportunity to participate in this study. Analysts of the Civil Maritime Analysis Department will be available as required to assist in interpretation of data. The ONI point-of-contact is Mr. Charles Dragonette on (301)669-3261.



EVAN D. ROBINSON  
By direction

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## **Appendix VII: Study design by Lloyd's Maritime Information Services**

### **1. Approach And Work Plan**

#### **Introduction**

Lloyd's Maritime is grateful for the opportunity to submit this proposal to assist the Center for Naval Analyses (CNA) in its study of the impact to merchant shipping in the event of a closure to the Malacca Straits and a military conflict in the South China Sea. The company has many years experience of performing similar studies for clients worldwide and has the expertise to carry out the work outlined in this document. The company has developed proven analytical systems over several years and has the insight into the shipping industry to interpret and assess the impact of a change to world trading patterns. The utilization of the existing models of world seaborne trade, the world fleet and specific knowledge of the international maritime industry will enable the individual members of the Study Team to concentrate from the outset on analysis and interpretation as opposed to gathering trade and fleet data and model building.

The Center for Naval Analyses (CNA) is part of the U.S. Navy establishment, and, as such, Lloyd's Maritime has not factored in any charge for data in the study that is presently supplied to the Navy. The trade data required for the project will be acquired by Lloyd's Maritime from DRI/McGraw-Hill, under the auspices of the United States Army Corps of Engineers (USACE) contract with this supplier of trade data as contained in their World Sea Trade Service.

The objective of the LMIS input to the study is to assess the economic impact on merchant shipping of a closure to any of the waterways referenced above and calculate the consequential impact on the affected economies in Asia. In order to perform this, a wide range of

unique data sources and analytical skills are required. The Study Team must be able to:

- Determine the potential traffic through each region.
- Identify the routes the ships are operating on, and whether they are laden legs.
- Calculate the cost by ship size and type of a deviation.
- Link the transit of vessels to the movement of goods by commodity category and ship type.
- Calculate the effect the additional transport costs have on the landed prices of the main commodities.

The process by which the study will be performed is outlined below.

The first and most critical task is to determine the population of vessels which transited the Study Region in 1993. In the absence of physical sightings the only way that this can be established is by deriving the population by assessing the vessels which traded between geographic regions either side of the potential choke point and deciding, based on industry knowledge, and vessel itineraries, which of these were likely to have been routed through the region. To perform this element of the project, Lloyd's Maritime will analyze its vessel movements database to establish all vessels which are determined to have passed through the Malacca, Lombok and Sunda Straits. A similar analysis will be performed for all vessels which pass through the area termed the "South China Sea." For the purpose of this study, this is effectively the area from a line stretching from the Mekong Delta to the northern most tip of Sabah. To perform this element of work it is essential that the analysts are fully conversant with the individual trades and ship types. Lloyd's Maritime will utilize the skills of its specialist analysts in this element of the study as their knowledge of trading patterns will be essential to obtain an accurate analysis of the region. For example, the Europe/Far East container trade is both complex and diverse. Some operators service the trade differently and, therefore, the same assumptions can not be applied equally to all ships on the same trade route. Lloyd's Maritime detailed analysis of the major trade routes in the region, including the intra Asia trade, will be utilized in this section of the project. Equally, knowledge of

the long haul tanker trades obtained from the company's detailed analysis of the movement of oil by sea will be utilized to analyze the routing of crude and product as well as the ballasting voyages. Some vessels will return in ballast from discharge to load areas on a regular basis whereas others will be re-deployed. The population of each will have to be established from research and based on industry knowledge. All the vessels identified in this process will be allocated to a service type category to create the basis to allocate cargo to those vessels deployed on each route.

The key characteristics for each vessel which will include, flag, dwt, and nationality of parent company will be captured so as to enable analyses of the ownership profiles and capacity on each route to be performed.

Having completed the modelling of the existing trade patterns, the impact of four different scenarios will be assessed:

- (i) Closure of Malacca Straits.
- (ii) Closure of Malacca Straits and Singapore.
- (iii) Closure of Malacca, Singapore, Lombok and Sunda Straits.
- (iv) Closure of Sea Trade lanes around The Spratley's.

The displacement of tonnage brought about by each of the above will be evaluated in terms of the additional distances that have to be steamed and the effect this has on the supply of tonnage. In some instances this will take up excess capacity which will be welcomed by shipowners but will not necessitate an increase in the size of the fleet. In other cases there may be a need to migrate surplus tonnage to new deficit areas and in others there will be a requirement to build additional ships.

The consequential additional costs associated with the longer voyages will be assessed based on the average time charter rates for the various vessel types. Where appropriate, the average operating cost variances for the owners will also be reviewed.



The Port of Singapore is a major transshipment centre in this area, both for containerized and liquid bulk. The impact of a closure to the access channel to the Port of Singapore would have major consequences not only on the regional trade but also on international trade as a number of the leading container operators use the port as a transshipment centre for points as far as India to the west and Philippines to the north. The Consultants will consider alternate means of handling the transshipment cargo, however it is likely that the cargo for the western half of the region would be either transhipped in the Gulf or be carried on direct services, with the cargo to the north being transhipped in Hong Kong or other Chinese ports, some of which have yet to be developed.

Each of the requirements outlined in the Terms of Reference invitation dated May 1994, have been identified as a task and are included in this section of the workplan. The deliverables from each of the individual tasks in the study are described in Section 2 and include a flowchart of the workplan.

The Study Team recognizes the importance of ensuring that the personnel nominated by the CNA to manage this project are fully conversant with the work process and involved in the establishment of the assumptions used in the analysis. Throughout the project, the Project Manager and/or Mr. Mandryk, will involve the CNA nominated personnel in establishing the key criteria for the analysis.

## **2. Tasks**

### **Task 1 Identification of Vessels Using the Straits**

#### **Objective**

The objective of this task is to identify vessels passing the Spratley Islands and/or transiting the Straits of Malacca, Sunda and Lombok, hereinafter referred to as "The Study Region", in terms of:

- Type of vessel (see appendix A)
- Number of individual vessels
- Number of eastbound and westbound transits

- Number of northbound and southbound transits
- Nationality profile in terms of flag and ownership.

### **Steps**

The LMIS database will be interrogated to identify vessels observed to have moved through the region during 1993. The analysis will cover all cargo vessels, excluding ferries, over 1,000gt, broken down as shown in Appendix A.

By analyzing port rotation of individual vessels, transits will be broken down into eastbound and westbound voyages northbound and southbound aggregated by vessel type.

By referencing the Lloyd's Register number, LMIS will identify each unique vessel in order to build up a profile of the fleet in terms of:

- Number of vessels by vessel type
- Nationality of fleet by flag and owner.

### **Deliverables**

Table of all vessels transiting the area aggregated by type and broken down according to nationality of flag and owner.

## **Task 2 Identification of Voyage History of Vessels Using the Study Region**

### **Objective**

The objective of this task is to analyze the voyage patterns of vessels identified transiting passing through the Study Region.

### **Steps**

The LMIS vessel movements database will be interrogated to provide voyage histories for 1993.

The Consultants will utilize the following sources to determine voyage patterns:

- LMIS Liner database for longhaul liner movements.

- LMIS Intra-Asia liner database for regional liner movements.
- APEX (Analysis of Petroleum Exports) database for crude and product tanker movements.
- World Fleet analyzed movements database.
- Commodity statistics for other vessel types. By allocating cargo flows on each trade route to observed capacity appropriate to the commodities in question, it will be possible to identify laden moves by vessel type.
- LMIS charter fixture databases.
- Original market research.

Vessel movements will be aggregated by vessel type in terms of voyages and capacity (dwt/teu\* x number of voyages). Voyages will be broken down, according to nationality of flag and owner, in order to establish the relationship between vessel activity and nationality of flag owner. In respect of liner vessels, route allocation factors will be calculated representing the proportion of capacity offered by individual trade legs by vessels operating on multiple trade routes. Ballast assumptions will be made based on characteristics of each individual trade and vessel type.

\* where appropriate

## Deliverables

A table of vessels movements by trade route, aggregated by vessel type, and broken down by nationality of flag and owner. Trade routes will be based on the trade route matrix shown in appendix "B". In addition, voyage patterns covering movements of vessels to/from these areas will show individual countries to the rest of the world (aggregated). This will be analyzed according to the following countries:

- Malaysia
- Singapore
- Indonesia
- Taiwan

- South Korea
- Philippines

Should the client specify additional analysis of specific country data, the acquisition of such data and cost thereof will be subject to separate negotiation.

### **Task 3 Analysis of Voyage Patterns of Vessels Using the Study Region**

#### **Objective**

The objective of this task is to analyze voyage activity by geographic areas consistent with their relative dependence on the use of the Study Region.

#### **Steps**

Voyage activity, as identified under Task 2, will be broken down as follows:

- Straits (coastal) movements
- Regional movements
- Longhaul international movements.

Areas will be defined in terms of port ranges based on the following criteria:

#### **The Straits of Malacca, Sunda and Lombok**

Laden vessel movements confined exclusively to the coastal range around Malacca, Sunda and Lombok Straits. This will cover vessel movements both across and along the Straits. The data reported from this area is incomplete and, therefore, it is likely that the data relating to local movements around Sunda and Lombok will not be comprehensive.

#### **Regional**

Voyages confined exclusively to the South China Sea from a line stretching south of the Mekong Delta and northern most tip of Sabah

south to Indonesia. The data reported from this area is also incomplete.

#### **International**

Laden vessel movements confined exclusively to vessel originating/ending voyage legs outside the South China Sea area. International voyages will be further analyzed according to whether vessels load/discharge within the South China Sea and those merely transiting the area.

#### **Deliverables**

Data tables of vessel movements by vessel type, by area, broken down according to nationality of flag and parent company owner.

### **Task 4 Analysis of Sea Trade Lanes**

#### **Objective**

The objective of this task is to identify sea trade route by vessel type.

#### **Steps**

Sea trade routes will be plotted by vessel type based on:

- Trade route data identified under Task 2 including Canal Suez/Panama transit indicators.
- Industry standard routing charts.

In plotting the major trade lanes, due consideration will be given by the Consultants to physical constraints such as draft, breadth and range capacity.

Distances for each sea trade lane will be calculated utilizing BP distance tables between representative ports for each trade route.

#### **Deliverables**

A route and distance map of major sea trade lanes for each vessel type.

## **Task 5 Analysis of the Effects of Closing the Study Region**

### **Objective**

The objective of this task is to calculate the effects of closing the Study Region in terms of:

- Re-routing of trade
- Closure of trades

### **Steps**

The Consultants will calculate the effect of trade disruption under four separate scenarios:

- Closure of Malacca Straits to long haul shipping. Vessels divert to Singapore via Sunda and Lombok.
- Closure of Malacca and Singapore.
- Closure of The Spratley's to international longhaul traffic moving north/south of a line between the Mekong Delta and the north tip of Sabah south to Indonesia. Vessels diverted via Lombok.
- Closure of Malaysian, Indonesian and Singaporean waters vessels are diverted via Australia.

For each scenario the Consultants will calculate the deviation distance for alternative routings between the point of origin and destination on each trade leg. Routing options will take into account physical constraints, such as breadth and draft, particularly in relation to canal passings.

Once routing options have been established, additional steaming time will be calculated for each vessel type based on observed average speeds extracted from the LMIS movements databases.

Deviation costs for each major trade route and vessel type will be calculated in terms of:

- Additional charter hire cost for non-liner vessels.
- Operating costs for liner vessels.

- Cost of tying up capital (vessels and cargo).
- Impact on freight rates arising from increase in demand for capacity.

#### **Deliverables**

A matrix table showing additional costs incurred as a result of deviating vessels, broken down by trade route and vessel type.

### **Task 6 Analysis of Trade Flows By Vessel Type**

#### **Objective**

The objective of this task is to:

- Establish trade volumes and values by commodity for all trade routes.
- Allocate trade volumes by commodity to vessel capacity (by type) operating on each trade route.

#### **Steps**

In respect of each trade route (Appendix B) seaborne commodity flows by volume (tonnes) and value (USD) will be given broken down into 40 main commodity groupings (Appendix C). DRI WSTS trade database will form the basis of this analysis.

Each commodity will be allocated to the appropriate vessel type consistent with observed capacity on each trade route. By matching individual commodities to vessel types it will be possible to link base operating costs and deviation costs established in Task 5 to individual commodities. This will form the input for assessing the economic impact of each closure scenario by region and commodity in Task 7.

#### **Deliverables**

In respect of each trade route, a set of trade data tables covering 20 main commodity categories in terms of value and volume for the year 1993.

Matrix tables by routes and commodity showing:

- Base operating costs
- Additional deviation costs for each closure scenario.

## **Task 7 Economic Analysis of the Effects of Closure of the Study Region**

### **Objective**

The objective of this task is to assess the economic effects of closing the Study Region in terms of:

- Increased cost on landed price of commodities, by import region.
- Overall cost to importing regions.
- Impact on shipping supply/demand balances.

### **Steps**

The incidence and level per commodity of deviation costs relative to the total value and volume of imports for each importing region under each closure scenario will be assessed.

For each closure scenario, the additional capacity required in terms of ship years (equivalent to the amount of cargo that can be transported by a vessel in one year) will be calculated.

The effect that the distortion of trade will have on global supply/demand balances for each vessel type under each deviation scenario will be assessed by comparing additional ship years required with:

- The size of the laid up fleet.
- The overall level of over capacity in world fleet by reference to the LMIS/DRI World Fleet Forecasting Model which compares available capacity with demand on all of the major world trading routes.



**Deliverables**

For each closure scenario, a set of matrix tables both by country and main commodity group, showing unit and aggregate costs of deviating vessels will be produced. In addition an assessment will be made of the impact on world shipping supply/demand balances.

## Project Flow Chart

**TASK 4**  
Establish sea trade routes  
and voyage times

**TASK 1**  
Density Analysis of Straits transits

**TASK 2**  
Establish trading patterns

**TASK 3**  
Analyze trading patterns

**TASK 5**  
Calculate deviation costs for each  
closure scenario. Assess effect on  
freight rates.

**TASK 6**  
Establish trade volumes and values  
for each trade route identified in  
Task 3 by 40 major commodity  
groups and allocate volumes to  
major ship size types.

**TASK 7**  
Assess the economic impact of clo-  
sure scenarios in terms of:

- Additional cost per commodity  
by import region
- Additional cost by importing  
region
- Impact on freight rates
- Effect on supply/demand  
balances

## TASK 1

Define criteria for identifying passings

Output voyage data by vessel type

### **Design Database**

To analyze:

Westbound/Eastbound

Southbound/Northbound voyages  
(vessels owners flag)

Produce density analysis of vessels  
determined to have transited the  
study region.

**TASK 2**

Voyage transits to identify  
origin/destination  
regions

Identify laden voyages and  
relevant ballast legs

Aggregate voyages by vessel  
type and trade route to  
establish density and  
capacity

**TASK 3**

From the Task 2 allocations analyze trading pattern of each geographic area (Straits/ regional/ international)

**Straits**  
Establish capacity within area

**Regional**  
Establish capacity within area

**International**  
Establish capacity for trade to the area and transit voyages through the area

Aggregate voyages by vessel type and trade route to establish density and capacity

**TASK 4**

Allocate voyages established  
in Task 2 to sea trade  
routes

Calculate distances and  
determine average vessel  
speeds per vessel type

Calculate the average  
voyage times

**TASK 5**

Establish distance  
matrices for all  
diversion scenarios

**Scenario 1**  
Closure of Malacca  
Straits to long haul  
shipping. Ships  
diverted to Sunda  
and Lombok

**Scenario 2**  
Closure of The Sprat-  
ley's. Ships diverted  
from Malacca and  
Sunda to Lombok

**Scenario 3**  
Closure of Malaysian/  
Indonesian waters  
and The Spratley's.  
Long haul traffic  
diverts south around  
Australia

Calculate additional  
voyage time for  
each scenario and  
vessel type

Calculate deviation  
costs and assess  
consequential  
impact on freight  
rates

**TASK 6**

Establish trade volumes and  
values for each trade route

Allocate 40 main commodity  
groups by vessel size type by  
trade route

Link commodities to base  
operating and deviation  
costs



## TASK 7

Calculate proportion of deviation cost per commodity as a proportion of the overall cost of that commodity by importing region under each closure scenario

Aggregate additional deviation costs for all commodities by importing region

Calculate by vessel type additional capacity required to carry trade volumes under each closure scenario

Compare additional capacity required to size of laid up fleet and level of under/over capacity of world's trading fleet

Assess effect of closure on supply/demand balances and consequential impact on freight rates

### 3. Deliverables

#### Task 1

Summary table of vessels transiting the Study Region broken down according to:

- Strait
- Vessel type
- Number of unique vessels passing eastbound
- Number of eastbound transits
- Eastbound capacity (transits x dwt)
- Number of unique vessels passing westbound
- Number of westbound transits
- Westbound capacity
- Number of unique northbound vessels
- Number of northbound transits
- Northbound capacity
- Number of southbound unique vessels
- Number of southbound transits
- Southbound capacity
- Total number of unique vessels
- Total number of transits
- Total capacity

#### Ownership Analysis

Summary table of capacity transiting the Study Region broken down according to:

- Strait
- Vessel type

- Direction (eastbound, westbound, southbound, northbound)
- Nationality of parent owner
- Capacity (transits x dwt)
- Total capacity by Strait

#### **Flag Analysis**

Summary table of capacity transiting the Study Region broken down according to:

- Strait
- Vessel type
- Direction
- Nationality of flag
- Capacity (transits x dwt)
- Total capacity by Strait

#### **Flag/Ownership Analysis**

In respect of vessels flagged under the registries of Panama, Liberia and Cyprus and Bahamas, a breakdown will be provided according to:

- Strait
- Flag
- Vessel type
- Direction
- Parent owner nationality
- Capacity (transits x dwt)
- Total capacity

#### **Comparison with World Fleet**

Vessels transiting the study area will be compared with the world fleet in respect of vessel over 1,000 gt. Data will be analyzed in tabular format according to:

- Strait
- Vessel type
- Number of unique vessels
- DWT (No. vessels x dwt)
- Total number of vessels (Study Region)
- Total dwt (Study Region)

#### **Estimate of Shipping growth**

From the World Fleet Forecast movements database a tabular analysis of international voyage activity into/out of the area will be provided. Analysis will provide details of growth in percentage terms of voyages by vessel type for the years 1987-1993 covering:

- World to/from South East Asia

In addition, market research will be carried out into changes in regional trading patterns by the major type categories:

- Liner
- Dry bulk
- Liquid bulk

based on Port of Singapore statistics which as the dominant regional shipping centre is representative of the Study Region as a whole.

#### **Analysis of Shipping Trends**

For each country within the Study Region:

- Malaysia
- Singapore
- Indonesia
- Taiwan
- South Korea
- Philippines

A tabular analysis will be given of:

- Size of national fleet (number and dwt)
- Number of vessel calls by vessel type between each country pair within the region by vessel type.

### Task 2/3

Summary table of vessels transiting the Study Region, by trade route, broken down according to:

- Strait
- Vessel type
- Trade route
- Direction
- Ballast/laden leg indicator
- Number of unique vessels
- Number of voyages
- Capacity (voyages x dwt)
- Total number of unique vessels
- Total number of voyages
- Total capacity

In respect of liner vessels, route allocation factors will be calculated representing the proportion of capacity offered to individual trade legs by vessels operating on multiple trade routes. Trade routes will be broken down individually and also aggregated into four categories:

- Coastal trades
- Regional trades
- International trades from/to the region
- International trade transiting the region.

### **Ownership Analysis**

Summary table of capacity transiting the Study Region broken down according to:

- Strait
- Trade route
- Direction
- Nationality of parent owner
- Voyages
- Capacity (voyages x dwt)
- Total capacity by strait
- Total voyages

### **Flag Analysis**

Summary tables of capacity transiting the Study Region broken down according to:

- Strait
- Trade route
- Direction
- Nationality of flag
- Voyages
- Capacity (voyages x dwt)
- Total capacity
- Total voyages

### **Technical Report**

LMIS will provide a report explaining the methodology used for:

- Allocating vessels to each Strait
- Allocating vessels to trade routes

This process involves cross-referencing transit data with existing in-house databases for liner and tanker movements, and with trade and industry data for dry bulk vessels.

#### **Task 4 Analysis of Sea Trade Lanes**

For each trade route distances will be calculated between representative ports for representative vessel size ranges. Distance tables will be presented in tabular format (base distance matrix).

A graphical representation of sea trade lanes based on shortest operational distance between trading regions will be given.

#### **Task 5**

For each closure scenario:

- Closure of Malacca Straits to long haul shipping. Vessels divert to Singapore via Sunda and Lombok.
- Closure of Malacca and Singapore.
- Closure of The Spratley's to international longhaul traffic moving north/south of a line between the Mekong Delta and the north tip of Sabah south to Indonesia. Vessels diverted via Lombok.
- Closure of Malaysian, Indonesian and Singaporean waters vessels are diverted via Australia.

Deviation distances will be calculated for each vessel size range and presented in tabular format.

On each trade route vessels will be “deviated” via the shortest operational distance. Deviation distances for each trade route under each closure scenario will be added to the “base distance matrix”.

For each trade route and vessel type average speeds (distance/transit time/24) will be calculated based on observed transit times in the movements database and presented in tabular format.

A tabular analysis of daily vessel costs in U.S. dollars will be presented showing by vessel type:

- Charter hire cost
- Operating costs incorporating:
  - Crew costs
  - Fuel oil
  - Bunkers
  - Insurance
  - Repairs/maintenance
  - Administrative overheads
- Capital costs

Under closure scenarios where deviation option may involve additional canal transits, additional canal transit costs will be given by vessel type in tabular format.

From subsequent research (see Task 6 and 7) impact of extra deviation time for trade route and vessel type on cargo capital costs will be assessed and presented in tabular format. The effect, if any, of increased demand for capacity as a result of deviation on freight rates will be assessed and presented in tabular format.

A matrix of additional vessel cost by trade route and vessel type will be given as a function of additional deviation time x daily (operating cost or charter hire costs + vessel capital costs + canal cost + freight rate additional + cargo capital cost).

## **Task 6**

In respect of each regional and international trade route identified in the passing analysis, a matrix table of total commodity volumes and values will be given for the year 1993.



The proportion of cargo transiting the study region will be calculated based on:

- Research of individual commodity trades
- Comparison with available capacity

and the results presented in tabular format.

Commodities identified as moving via the study region will be allocated to appropriate vessel types for each trade route.

A matrix table by trade route will be given showing for each closure scenario, deviation costs per commodity. Deviation costs will be a function of deviation cost per vessel type relative to the proportion (percentage) of each commodity allocated to that vessel type. Additional incremental transport costs by commodity and destination will be given showing:

- Cost as a percentage of value by trade route.
- Deviated cargo as a percentage of total trade in or out of the region.

## Task 7

A matrix table will be given by trade route of the additional cost added to the overall value of seaborne trade under each deviation scenario. Data tables will be broken down by commodity and aggregated by trade route.

A tabular analysis will be given globally by ship type of additional capacity required under each closure scenario in terms of:

- Ship years (based on calculating the amount of cargo that can be transported by a vessel in one year on given trade routes)
- DWT capacity (no. of vessels X DWT)

A comparison will be made for each vessel type with existing under/over capacity within the world's trading fleet derived from LMIS/DRI

World Fleet Forecasting Model. A comparison will also be made with the size of the laid up fleet by vessel type.

Based on projected effect on fleet supply/demand balances, a tabular analysis will be produced for each closure scenario estimating likely impact on:

- Charter hire cost for non-liner vessels
- Freight rates for liner vessels as a function of increased operating/capital cost divided by vessel utilization.

## 4. Appendixes

### APPENDIX A

General Cargo	>10,000 DWT
General Cargo	<10,000 DWT
Cellular	<1,000 TEU
Cellular	1,000 to 2,499 TEU
Cellular	2,500 to 3,999 TEU
Cellular	4,000 to 5,999 TEU
Ro-Ro	>10,000 DWT
Ro-Ro	<10,000 DWT
Bulk	<20K DWT
Bulk	20K to 40K DWT
Bulk	40K to 80K DWT
Bulk	80K to 100K DWT
Bulk	100K to 175K DWT
Bulk	>175,000 DWT
Combo	<20,000 DWT
Combo	20K to 40K DWT
Combo	40K to 80K DWT
Combo	80K to 100K DWT
Combo	100K to 175K DWT
Combo	>175,000 DWT
Tanker	<16,500 DWT
Tanker	16,500 to 24,999 DWT
Tanker	25,000 to 44,999 DWT
Tanker	45,000 to 79,999 DWT
Tanker	80,000 to 159,999 DWT
Tanker	160,000 to 249,999 DWT
Tanker	>250,000 DWT

*Appendix VII*

Product Tanker	<16,500 DWT
Produce Tanker	16,500 to 24,999 DWT
Produce Tanker	25,000 to 44,999 DWT
Produce Tanker	45,000 to 79,999 DWT
Produce Tanker	80,000 to 159,999 DWT
Reefer	
Gas Tanker	
Vehicle Carriers	
Other Ships	

## WFFS ROUTE MATRIX

Route	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	27	28	50	51	52	53	54	55	Route
1																																	1
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APPENDIX B

## ROUTES

Route code	Route	Route code	Route	Route code	Route	Route code	Route
1	US EAST COAST (NORTH)	10	JAPAN	19	OTHER MED	50	MALAYSIA
2	US EAST COAST (SOUTH)	11	SOUTH PACIFIC (AUS/NZ)	20	EAST EUROPE (NORTH)	51	SINGAPORE
3	US GULF COAST	12	FAR EAST NIC'S	21	CHINA/NORTH KOREA	52	INDONESIA
4	US WEST COAST (SOUTH)	13	SOUTH AMERICA EAST COAST	22	SOUTH EAST ASIA	53	TAIWAN
5	US WEST COAST (NORTH)	14	SOUTH AMERICA WEST COAST	23	INDIAN SUB CONTINENT	54	SOUTH KOREA
6	CANADA EAST COAST	15	EAST AFRICA	24	CARIBBEAN	55	PHILIPPINES
7	CANADA WEST COAST	16	WEST AFRICA	27	EAST EUROPE SOUTH		
8	NORTH EUROPE	17	SOUTH AFRICA	28	RUSSIA FAR EAST		
9	SOUTH EUROPE	18	ARABIAN GULF				

**APPENDIX C**

- 1 Live animals
- 2 Meat, fish and dairy products
- 3 Fruit and vegetables
- 4 Grain, animal feedstuffs
- 5 Sugar
- 6 Flour, other food preparations, beverages and tobacco
- 7 Animal skins, textile fibres and waste
- 8 Oilseeds
- 9 Animal and vegetable oils and fats
- 10 Rubber
- 11 Lumber, plywood, logs and processed wood
- 12 Pulp and waste paper
- 13 Phosphates and other natural fertilizers
- 14 Cement, lime, stone and other crude minerals
- 15 Manufactured fertilizers
- 16 Iron ore
- 17 Bauxite and ores of other base metals
- 18 Other ores and scrap
- 19 Coal and Coke
- 20 Crude petroleum
- 21 Other petroleum products
- 22 Natural and manufactured gases
- 23 Liquid bulk chemicals
- 24 Other chemicals
- 25 Pharmaceuticals, toiletries
- 26 Explosives, plastics, chemical products
- 27 Leather and rubber materials, textile yarn and fabric
- 28 Paper and paper manufactures
- 29 Other non-metallic mineral and metal manufactures
- 30 Iron and steel
- 31 Non-ferrous metals
- 32 Heavy industrial machinery and equipment
- 33 Light industrial machinery and equipment
- 34 Heavy transportation and construction equipment
- 35 Automobiles

- 36 Motorcycles, automotive parts
- 37 Aircraft and ships
- 38 Electrical equipment and parts
- 39 Consumer goods
- 40 Commodities nad transactions NES

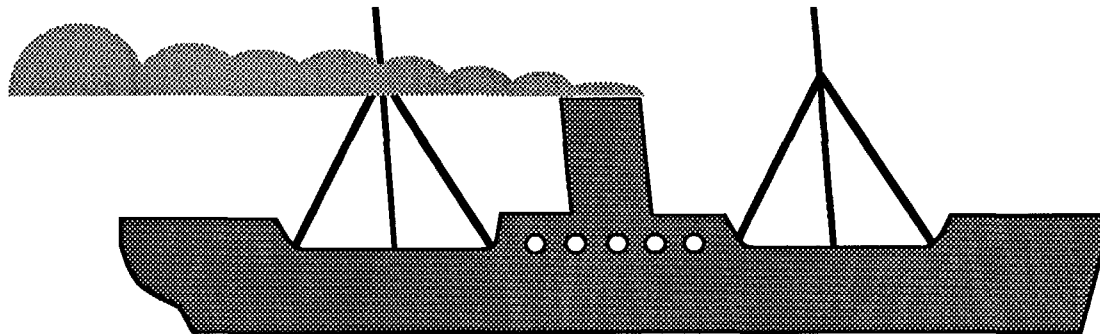
## **Appendix VIII: Brief to CNA President**



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# ***Study Brief***

## ***'Value of Trade in South East Asia'*** **A Strategic Trade Study**



**To: Mr. Robert Murray**  
**By: John Noer**  
**For: Regional Studies Program**  
**27 May, 1994**

## ***Study Purpose***

- ***N3/N5 Interest: the National Policy Guidance assigns the Navy the mission of keeping open the SE Asian sea lanes***
  - *What are our economic national interests?*
- ***Approved Study Proposal: to determine the economic consequences of blocked sea lanes in SE Asia***
  - *Extra miles steamed + longer time in transit = higher cost*
  - *How much trade would port blockage halt?*
- ***Use of Results: input to USN decisions on peace-time deployments and crisis response***
  - *Who are we protecting...the US, our allies, others?*
  - *How much presence is required? Where?*

# *The Value of the Study*

## ■ *Do we already know the answers? No*

- *existing estimates are imprecise, assumption based*
- *none estimate cost as % of import bill, GNP*
- *none analyze impact by country, flag, ownership*
- *none address both diversion costs & embargo effects*

## ■ *Can we answer the questions? Yes*

- *we have identified adequate, detailed databases*
- *we have the right methodology*
- *with support, we can respond quickly & accurately*

## ■ *Will we have impact? Yes*

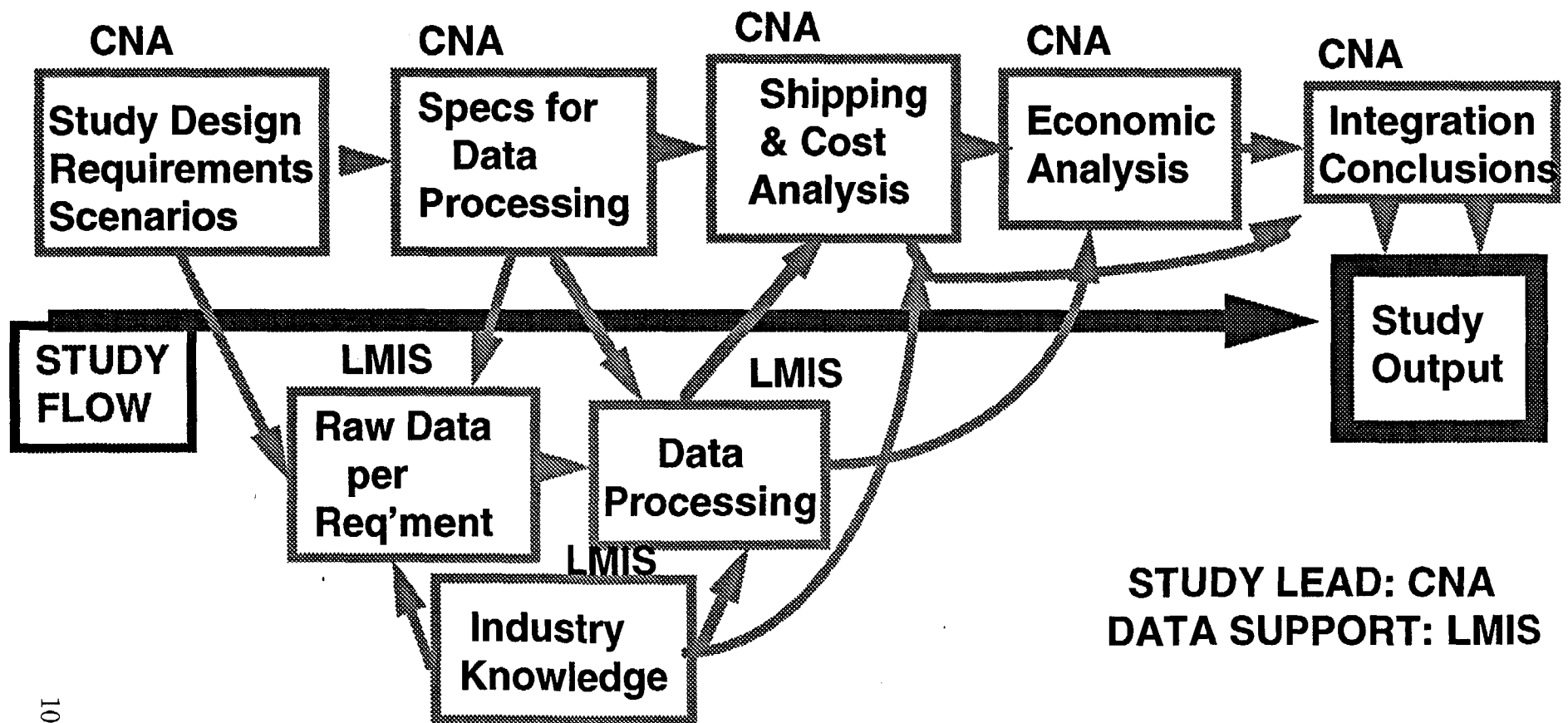
- *factor economics into forward-presence strategy*
- *methodology can be used to address other important SLOCs, determine global priorities*

## ***Study Data Needs***

- ***To make a contribution, good data is vital***
- ***There are two sources: ONI & Lloyd's***
- ***ONI has no trade data; is intel focused***
  - ***they recommend that we go to Lloyd's directly***
- ***Lloyd's data resources include:***
  - ***Ships Particulars File: detail on merchant ships***
  - ***Ship Movements File: international merchant voyages***
  - ***Charter Fixtures File: freight rates & charters***
  - ***World Commodity Trade: 20 commodities/200 routes***
  - ***APEX: sources, routes & destinations of crude oil***
  - ***Other data: Port data, liner data, vessel traffic counts, vessel operating costs, commodity prices***

# Study Strategy: Division of Labor

## Management & Analysis: Center for Naval Analyses



Data Inputs: Lloyd's Maritime Information Services (LMIS)

## ***Lloyd's Purchase Order***

- ***Lloyd's can provide processed data, necessary to do the work***
- ***Lloyd's would not charge us for the raw data***
  - *acquiring raw data could cost much more than the PO*
- ***Best option: high quality, fast turnaround, low cost (@ 1/2 MTS)***
- ***Alternative #1 - We buy and process data***
  - *Cost: at least 4-5 MTS + data    Time: at least 1 year*
- ***Alternative #2 - We rely on less accurate and comprehensive data***
  - *Result: weak study, can't measure impact by country*
  - *We would fall far short of CNA's analytic standards*

## **Appendix IX: Approved Project Plan**



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**Project Plan  
for  
Value of Maritime Trade  
in Southeast Asia**

**Background and issues**

The Malacca Strait is the second busiest sea lane in the world, and much shipping travels through the South China Sea. Malacca Straits transit might be inhibited by acts of adjacent powers, and war might be a threat in the South China Seas over the Spratlys. The United States deems that free transit via sea lanes through these waters to be a national priority, with the U.S. Navy given the primary responsibility for this mission. For these reasons the Deputy Chief of Naval Operations for Plans, Policy and Operations asked CNA to conduct a study assessing the economic impact of disrupting these waterways. Issues addressed in this study include: What is the economic element of the United States' national interest in these waters? How much would it cost the U.S. or world economy if these sea lanes were blocked? Which economies would be most affected?

**Objectives**

For a range of scenarios, we wish to measure how much it would cost for shipping to detour by longer routes, if these sea lanes were closed. We wish to estimate the incidence of these cost "shocks" by type of commerce (e.g., oil) and by affected country (e.g., Japan). Finally, we want to measure the economic consequences of actual blockage of ports in the region. These results will help the U.S. Navy properly deploy forces in peacetime to deter such contingencies. The study will contribute to decisions on how the U.S. might respond to potential disruption by identifying the economic stakes involved, including the stakes of countries which might wish to cooperate with us.

**Approach**

We will develop three scenarios:

(I.) Malacca Straits closed (long haul traffic diverted to Sunda or Lombok Strait); (II.) Mid South China Seas closed (long haul traffic is diverted to Lombok-Makassar); and (III.) Indonesia and Malaysia waters closed (long haul traffic detours around Australia). For each, our approach is to first calculate the direct transport costs caused by the (unspecified) blockage of the sea lane in question, using a transportation model. We will systematically identify merchant vessel movements and voyage patterns in the region, and tie them to commodity trade flows. We will then link the detour and delay costs to trade routes. These transport costs will then be translated into economic impact evaluations for diverted trade. The magnitude of trade 'blockages' will be estimated. Our approach will first assume traffic diversion and estimate the economic costs of rerouting cargoes. Then we will assume certain ports are closed and estimate the amount of trade that would be unable to move. Finally, we will evaluate the economic significance of both these events.

**Tasks**

**Task 1: Data and Methodology Study Plan.**

The data base is immense and comes from many disparate sources. The analysis relies entirely on calculations based on empirical data. The output of task 1 will identify data

sources, define calculations to be performed, and outline the study strategy and logic. We expect to complete this task in June 1994.

**Task 2: Identification of Vessels Transiting the Study Region.**

We will pass a world merchant vessel movements data base through a locational filter, to identify every single vessel known to transit the study area in 1993. We will generate a breakdown of vessels by flag, nationality, capacity, and type of vessel. We will then analyze the voyage histories of these vessels, to identify shipping patterns in the region. We expect to complete this task and present an interim briefing to the sponsor in August 1994.

**Task 3: Voyage Patterns and Sea Lanes.**

Voyage patterns will be analyzed by type of movement (local, regional, and long-haul international) and shipping density of sea lane (movements and capacity.) Commodity movements over these sea lanes will be identified, grouped in twenty major cargo categories. (We expect to complete this task and present an interim briefing to the sponsor in October 1994.

**Task 4: Impact of SLOC Disruption on Vessel Movements.**

For three scenarios, SLOC diversion patterns will be identified and the costs to shipping by nationality, type, and route will be estimated based on charter rates. Impact on fleet capacity and vessel charter rates will be analyzed. We expect to complete this task in October 1994 and will incorporate the results into a final briefing and final report, to be delivered to the sponsor in November 1994.

**Task 5: Economic Evaluation of SLOC Disruption.**

For each scenario, the impact of increased shipping costs on national economies will be estimated, as will the increased costs of commodities in transit to final consumers. For port blockage, the total number of affected ship movements and commodity shipments will be estimated. We expect to complete this task in November 1994.

**Task 6: Final Report for Sponsor Review.**

The study results will be integrated, to support conclusions based on the data and analytic exercises outlined above. The report will estimate the costs and economic impacts of each scenario by vessel ownership, flag, and economy. We expect to provide preliminary results in November 1994 (assuming the CNA Project Director is available at that time) and forward a final report for sponsor review in February 1995.

## Proposed deliverables

We will produce the following deliverables:

Task	Type of deliverable	Planned delivery date
2	Interim Briefing	August 1994
3	Interim Briefing	October 1994
4,5 & 6	Final Report	February 1995

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## **Distribution list**

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**N513F**

Attn: CDR. Sestak

Attn: LCDR. O'Callaghan

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